

LIGHTING BY ACETYLENE

FREDERICK DYE

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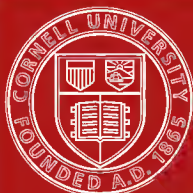
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LIGHTING BY ACETYLENE

LIGHTING BY ACETYLENE

A TREATISE FOR THE
PRACTICAL LIGHTING ENGINEER

CONTAINING ELEMENTARY INFORMATION AND DETAILS FOR
THOSE ABOUT TO TAKE UP THE WORK

BY

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CONSULTING ENGINEER



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PREFACE.



THE lighting engineer who takes up Acetylene will now or very soon find a wide and profitable field for this branch of his business, provided he goes the right way to work. The light is good ; the process of making simple ; and those who have studied and become experienced with this new commercial illuminant can and do rightfully say that it is perfect in a general and very broad sense.

Acetylene is an explosive gas, differing little from coal gas in this respect, and there have been accidents ; but in practically every case they are distinctly traceable to either dense ignorance or carelessness ; and, considering all things, their number has been few. Where trouble of a real kind has arisen, it has been in the generators placed on the market. Of course a good generator is the outcome of experience, and bad ones may be expected at the beginning ; but makers will not always see that their machines are bad, and the result is a more widespread condemnation of the gas than would otherwise be the case. These unsatisfactory generators have been mostly weeded out now, but they have given Acetylene a

character that it in no way deserves, and which, at the time of writing, clings too persistently to it.

The purpose of this treatise is—firstly, to make clear what is good and bad in Acetylene, or, it may be better said, to show how its good qualities can be obtained, and bad ones avoided or not created. Secondly, to be a practical guide to the engineer or fitter undertaking this work. It is believed that all information is afforded which will enable any lighting engineer or fitter to erect an apparatus correctly from beginning to end, and to judge the qualities of the generator he is purchasing or fixing. Briefly, it is a treatise written expressly for those erecting or intending to erect these works, and needing either general information or details of construction.

By the perusal of these pages and the exercise of ordinary care, there need be no hesitation in undertaking acetylene lighting works with every assurance of giving satisfaction. The time of doubt in this respect is past if the tradesman only exercises judgment with the generator. Acetylene may correctly be said to have no faults inherent to it : faulty qualities may accompany the gas as it comes over from the generating chambers, but they can be readily dealt with and remedied. Even the gas which comes over from generators which create faulty qualities can be simply treated and made good, though such generators are wasteful both of gas and material.

The general qualities and effect of Acetylene cannot be too highly spoken of, if it be properly made. A good generator will yield gas which will compare favourably in cost with coal-gas for a given light, at 3s. 6d. per thousand feet. It will need no more attention than can be given by a lad, farm-hand, or female servant ; and the attendance need not exceed from five to ten minutes per day for a fair-sized plant. The gas need have no objectionable qualities whatever, and the light itself is the most agreeable known. The writer can bear out these statements by experience ; for, apart from the number of complete plants erected to order, his own home is lighted throughout by this means, and an apparatus is in regular use at his works. The attendance and up-keep of the plant should cost practically nothing.

FREDERICK DYE.

OAKLEY, NEAR BISHOP'S STORTFORD,
HERTS.

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INTRODUCTION.

WITH AN ELEMENTARY DESCRIPTION OF THE PROCESS
OF ACETYLENE GAS PRODUCTION, ETC.

THERE is not the least doubt now about Acetylene Gas being commercially applicable to the many purposes for which artificial light is needed, particularly in places where coal gas and electricity are unavailable and only oil illumination otherwise possible. It can now be said quite positively that this gas is the light of the future for country houses and works, unless, of course, something better and cheaper should be devised, which is very unlikely.

Acetylene can now be made (given a proper generator) by a lad or any unskilled person, without supervision and with no risk; and it can be had at a cost that compares equally with coal gas at about 3s. 6d. per thousand feet for a given candle-power or brilliancy of illumination. This is after allowing for wear and tear and interest on outlay. Should the present price of carbide go down, or should its gas-yielding qualities be increased, then acetylene will compare, of course, more favourably still.

The present cost of the gas, however, is no obstacle to its free adoption, for it is in very few country places that coal gas costs less than 3s. 6d. per thousand feet, and in many districts it exceeds this greatly. Probably most people would rather pay a little more for coal gas supplied by a gas company, as the trouble of making the acetylene, small as it is or should be, is still a trouble, and the outlay for the apparatus has to be considered. Therefore acetylene is unlikely to displace coal gas where the latter exists ; but it is already a possible and strong rival to coal gas if it should be a question of which gas plant shall be laid down to light a village. For single-residence plants acetylene has nothing to fear from coal gas, neither need it fear much from gasoline, which is dirty, ill-smelling and expensive in comparison with the later illuminant. Gasoline is also more dangerous.

As to how acetylene compares with paraffin oil in cost, there is much uncertainty. One authority puts oil as costing double as much as acetylene for a given light, whilst another says oil costs little more than half as much. There can be no doubt of the former being correct for a given light, but it is not quite the correct way to compare the two. When oil is used a comparatively dull light is obtained, and this is considered satisfactory for oil. If an acetylene plant is then substituted, the degree of light given by the lamp is considered insufficient, and a much more brilliant effect is looked for and insisted on. Then the second authority quoted comes nearer truth ; and from inquiries made by the writer from the users of the many acetylene apparatus he has erected, it may be stated that the average of these shows that acetylene costs about 20 per cent.

more than oil, but a superior degree of illumination is obtained. Acetylene, however, can show a saving of labour, for the apparatus the writer uses only takes about five minutes per day for recharging—equivalent to the time taken on two lamps in wick-trimming and refilling. It may also be mentioned that the lamp room of a large country house is a far greater menace to its safety than an acetylene generator in its hut outside.

To give an outline of acetylene gas production and consumption in an elementary way, for those whose experience is very limited, the manufacture of the carbide need not be considered. The carbide (carbide of calcium) consists of lime and carbon (coke) fused together, and is to be readily purchased in any quantities from the different factors now stocking it. This carbide is a dry, grey material much resembling ordinary gas coke, but is denser and heavier. While it is kept dry it remains unchanged, and is perfectly safe even if fire should attack it. The change comes when water is brought in contact, and the carbide is so susceptible to this, and so greedily absorbs moisture, that the little water-vapour there is in the atmosphere is quite sufficient to attack it and start gas production. It is therefore important that carbide be kept in air-tight drums or vessels, and these should be kept in as dry a place as possible in case of a fissure or loose lid.

When water is brought in contact with carbide, an immediate change occurs. The lime is slaked, hydrogen gas is given off, and this carries the carbon with it. In other words the resulting gas is carburetted hydrogen, and the spent material left behind is slaked lime. It will therefore be seen that the manufacture (if this is

not too great a word) of acetylene gas is simplicity itself—either some carbide thrown into water, or some water thrown on to the carbide.

Where individual skill is displayed, and much needed, is in arranging for the carbide and water to come together in an apparatus in which the gas can be conveniently stored and then conveyed away for use; and it is equally requisite that the removal of the spent material and the recharging with new be simply and effectually done, without waste or risk. That this aspect of the question has had consideration can be judged from the fact that several hundred patents connected with generators have been taken out, and probably there will be as many more.

The details of acetylene generation need not be given here, as it is fully described later (see page 50). It may be assumed that a generator is chosen and it is necessary to fix it. A hut or house is prepared to receive it, outside the building which is to be lighted. The generator must not be fixed in a room or cellar beneath the house. The generator house must be very sheltered, or preferably heated by hot water or steam to prevent frost attacking the plant. Whatever kind of generating apparatus is used, water is in it somewhere, and trouble must ensue if this freezes. Some consider that a brick-built generator house, with the doors lined with felt, can be protected by a good sized box of fresh horse manure (in which fermentation is set up). The writer has not had occasion to try this, but it sounds feasible.

Having made the necessary water connections to, and the gas connections from the generator, it has to be considered whether the gas should be purified. In any case, whatever the gas is used for, it should pass through

water first, and the majority of generating apparatus provide for this. The evolution of the gas is accompanied by heat, much the same as when ordinary quicklime is slaked, and the gas whilst warm carries vapours that can well be dispensed with. Condensation of these vapours is easily effected by passing the gas through cold water.

The condensation of condensable vapours, however, is not complete purification ; and for residence work, or any other than, say, such places as brick works or comparatively open factories, a purifier must be used. This appliance removes the gases which pass unchanged through the condensing process, but which, if burned, cause a haze and an odour which cannot be endured in the rooms. It is peculiar that, in trying an apparatus *minus* a purifier, there may be no haze or smell for several days ; then there comes a bad day, which shows how necessary the purifier is. It also shows, however, that much of the carbide is good enough to yield a pure gas, and that a purifier is chiefly necessary to deal with occasional bad pieces or quantities of material.

If a purifier is used (and fully three-fourths of the works erected need one), the gas service is taken from the holder directly to it, with perhaps no more than two or three feet of pipe between. If there are condensers, or water chambers for condensing, in the generating apparatus, the gas would, on leaving the generating chambers, first go through these, then proceed to the holder. As the gas leaves the holder it next has to pass through the purifier, and finally passes directly to the house. It is best not to put the purifier between the generator and holder, although at first thought it might be considered correct to do so. A purifier gives best results if the gas

passes through it slowly and as regularly as possible. This result is best attained on the house side of the holder. If placed between generator and holder the gas rushes through too quickly, and the general effect is not so satisfactory.

The service piping is arranged much the same as is ordinary gas piping, except that the pipes may be much smaller. At the lowest point in the piping (usually where the gas first enters the house), there should be a syphon-box, or some such provision, to receive the water that will collect in gas pipes. This is an ordinary provision with any gas-piping system, to dispose of "water in the pipes," as it is called.

An appliance that should appear in all but the smallest installations is a "governor." This is not a contrivance especially for acetylene installations, but is used in practically all coal-gas piping systems unless very small. It is a pressure regulator, which automatically controls the pressure of gas in the house services. If only one burner is alight, the issue of gas will not be stronger or cause the flame to flare more than when all are alight; and when the latter is the case, the amount of gas allowed to pass is only that which will allow all the flames to burn quietly and to best advantage.

The governor proves of greater advantage with acetylene than with coal gas, as any extravagance with the former means a greater waste of money than with the latter. It takes approximately fifteen times the volume of coal gas compared with acetylene to afford a given light for a given time; therefore in the case of waste a certain amount of acetylene, say a cubic foot, being wasted is equal to losing 15 cubic feet of coal gas. In other

words it is, as regards monetary loss, much more desirable to prevent waste of acetylene than coal gas. The governor will do this quite satisfactorily.

Having described the general arrangement of the various appliances included in a complete plant, a sketch (Fig. 1), is given, to make the description more readily

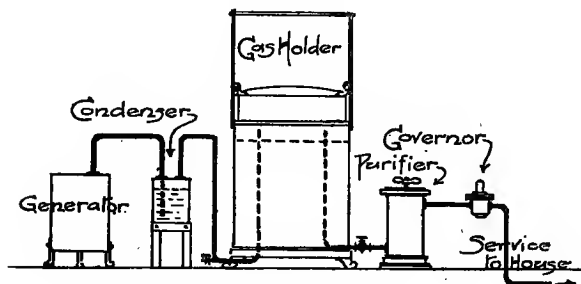


FIG. 1.

understood by those new to the work. Neither shape nor form is given to the generator, as no particular make can be inserted here. The sketch is merely to show the order in which the parts come. They need not necessarily be in a line, but as a rule they are all in the generator house.

As regards leaks in pipes, a slight issue of gas may not be considered any more dangerous than such a leakage of coal gas, but it represents a greater monetary loss. As just stated, if a cubic foot of acetylene leaks from a fissure in one hour, the cost is equal to about fifteen such leaks in coal-gas piping.

Respecting the sizes of gas services, the following are those customarily used, allowing for the pressure being reduced by the governor. With higher pressures,

smaller pipes would suffice, but higher than normal pressures give distinctly bad results.

A fuller table will be found at end of Chapter II.

Number of 25 c.-p. Lights.	Size of Pipe.	Number of 25 c.-p. Lights.	Size of Pipe.
2 . . .	$\frac{1}{8}$ -inch.	35 . . .	$\frac{5}{8}$ -inch.
5 . . .	$\frac{1}{4}$ „	50 . . .	$\frac{3}{4}$ „
10 . . .	$\frac{3}{8}$ „	70 . . .	1 „
20 . . .	$\frac{1}{2}$ „		

Ordinary iron gas tube is used, also compo pipe, but the latter would not appear in good work. The pipe should be given a rise all the way from its starting point, or from the syphon-box previously alluded to. This is the customary provision with all gas-piping systems.

The brackets, pendants and fittings can be of ordinary good quality, but there are now special fittings being made, and it is desirable to use them. Acetylene is described as a searching gas, meaning that it will find (pass through) a smaller and less important leak than coal gas; consequently a badly made fitting, or the wear and tear of well made ordinary fittings, is sooner brought to notice. The special fittings are made so that they are being perpetually ground in as they are used, and this keeps them sound much longer. This applies to the wearing parts, of course—the cocks, bracket joints and cup-and-ball joints. No fittings nor tubes nor any other parts should be of copper. Brass, although it is an alloy of copper, may be used freely.

The burners used for acetylene are specially made for this gas, and their general description will be found later. What has to be mentioned here, is that the burners should be kept of one candle-power or size as far as possible. The reason is that burners of different candle-powers require different pressures of gas to give

the best results. Burners varying five or even ten candle-power do not show any difference to speak of, and this degree of variation is permissible ; but to have 20 and 50 candle-power burners on the same piping must result in one or the other being less effective or less economical than it should be, unless the governor is adjusted for the large burners and the bracket taps are carefully adjusted for each smaller one. It is better in such a case to have double burners for the large ones—a burner that gives two 25 candle-power flames. This reduces the variation in size of burners to 5 candle-power only, and this, as stated, is quite permissible. These double burners are illustrated further on.

A 25 candle-power burner is the size generally used for residence work, or any living room, and this is the most desirable size as a rule ; but there remains the fact that the larger the burner the more economical of gas it is, or perhaps it should be said the more candle-power one gets per cubic foot of gas burned. Therefore, if an installation required a number of 50 candle-power burners, then it would be more economical to use these and trust to the bracket taps being regulated for the smaller ones ; or, better still, to try and arrange for all the small burners to be on a separate service, and put a separate governor to them.

For ordinary purposes a 25 candle-power flame is allowed to each 100 superficial feet of floor space, for lighting living rooms. It will be noticed that a 25 candle-power lighting flame, not burner, is mentioned, for burners vary much in their rated candle-power and the candle-power of the flames they give.

When the apparatus is thus completed it has to be tested, and this is done from the house side of the

governor, as the test must be of a higher pressure than the governor would allow unless its inner mechanism were removed. The appliance used for this will be found further on, but it need not be purchased—it can be readily made. It is customary to test with a pressure of 10 inches of water, and good work should not only bear this but much more. After testing, the gas can be turned on, and the working pressure then fixed by attaching the testing apparatus to a bracket, and adjusting the weights of the governor until a 2-inch pressure is obtained there. A $2\frac{1}{2}$ -inch pressure gives the best results with burners of 20 to 25 candle-power, but with burners of higher power 3-inch and 4-inch pressures are needed.

It may be assumed that the apparatus is now complete and ready for immediate use. Before applying lights to the burners, however, it is as well to give a thought as to whether there is any air in the apparatus. Air mixed with the gas is, of course, an explosive mixture, and this should be discharged before lighting up. It is stated that an explosive mixture would not light back along the tubes from the gas flame, because the aperture in the burner is too minute to admit of it. This is correct ; yet for fear of any unlooked-for condition, it is best to discharge part of the first volume of gas to waste, to make sure of all the air being got out of the apparatus. After this the air needs no consideration, as it does not again become associated with the gas except at the burner tips.

A last word should be said as to the re-charging of the generating apparatus. Having started the apparatus, it only remains to give the future attendant his directions as to re-charging. One important thing is to caution everyone against taking artificial lights to the gas-house.

An electric hand lamp would be permissible, but nothing else. No such light should be needed, as re-charging could be done in daytime. A conspicuous notice of these things should be attached to the door of the generator house.

The store of carbide can be kept in the same house as the generator, or in any adjacent dry place. It must not be kept on or under the building that is lighted, or any insured building. In every case the Fire Insurance Company must be apprised, and their rules (if they issue any) adhered to.

The spent material should be white, or very nearly so, and odourless. It then consists of slaked lime with a little excess water, and it may be used for practically any purpose to which such lime can be put. It may be used for walls, trees, etc. It will not pay, however, to attempt to dry it for any purpose. If the spent material gives off any odour of gas, it shows either that the apparatus does not use up the carbide properly or that the attendant is careless in re-charging before it is quite necessary. At the same time there are generators made with which it is difficult to wait until the carbide is all spent, as this might be after dark, when re-charging is awkward or impossible and when the gas is needed for use. Such a generator is not the best one to use for private residence work ; but if one exists, then when re-charging, the attendant, has to sort the contents of the generating chamber, picking out the partially decomposed pieces and putting them back with the charge of new material. It is not a convenient arrangement, yet it must be done in such cases to admit of daylight re-charging. With such generators it is difficult to get a sludge odourless and free of gas, therefore the spent material should be dumped into a tub or pit containing water.

CHAPTER I.

CARBIDE OF CALCIUM (CaC_2).

A Brief History.—It must be understood that several metallic substances lend themselves to combining with carbon to form carbides, all of which decompose in water and give off the gas Acetylene. There is no doubt that Professor E. Davy, of the Royal Society, Dublin, first discovered the gas by accidentally making a carbide with potassium, and noticing that it decomposed in water and that the resulting gas burned with a brilliant flame. He recognised that the gas was a new discovery, and went to considerable lengths to determine its different properties and qualities. He gave it as his opinion that the gas was well adapted for purposes of artificial light, provided the carbide could be made or obtained at a commercially cheap rate. This was as early as 1836.

Nearly thirty years later, in 1862, a German chemist produced a carbide of calcium, he having subjected some carbon to a very high temperature with an alloy made up of zinc and calcium. It was practically the carbide of calcium we now use, except for the presence of the zinc. He also went to some trouble to discover the nature and properties of the gas that was evolved on wetting the carbide, but found no way of making the carbide commercially cheap. Following this discovery came others, chiefly showing that several compounds could be

made to produce acetylene, but none cheap enough for producing the gas at a moderate price.

The writer is unable to ascertain clearly whether it was recognised at the time that lime and carbon, if chemically united, would produce carbide of calcium at the desired degree of cheapness. It appears to have been discovered more accidentally. In 1892 a French scientist, H. Moissan, in experimenting with an electric furnace, noticed that the walls of the chamber, consisting of lime, fused into a liquid state at a temperature of 3000°C ., and there occurred a combination between it and the carbon of the electrodes, producing carbide of calcium, which he quite easily collected. Following up his investigations, he presently obtained the pure crystalline carbide by merely subjecting powdered lime and carbon to the action of his furnace. At this time he read a paper before the Académie des Sciences, giving a full description of its physical and chemical properties, deciding its chemical formula, and showing how readily it produced acetylene.

It was also in the year 1892 that T. L. Willson, in experimenting upon the reduction of metallic substances in an electric furnace, found that, having had lime with tar and other forms of carbon in his furnace, he obtained "a hard crystalline mass which gave rise to a violent evolution of gas when brought into contact with water, the gas being inflammable and burning with a smoky flame." Having recognised the value of his discovery, Willson obtained a patent in America, No. 492,377, February 21, 1893, and commenced the manufacture of calcium carbide on a large scale, at Spray, in North Carolina.

From all that can be learned, Moissan and Willson made their discoveries and pursued their investigations.

quite independently, unknown to one another, but at about the same time. Moissan's researches, however, were conducted purely from a scientific point of view, while Willson, grasping the possibilities of the situation, studied the commercial aspect. In 1896 Willson applied for a special Act of Parliament to antedate his English patent, which, by error, had not been filed with the date of the American application. Willson now holds the patents for England and America, but at the time of writing there are rumours of legal proceedings which may, or may not, affect them.

Electric Furnaces for the production of Carbide of Calcium.—At present there are no practical means of producing calcium carbide except by the electric furnace, and to run this with sufficient economy water-power must be used.

The electric furnace used by Moissan was such as might appear in a laboratory for experimental work. It resembled Fig. 2, and consisted of two blocks of lime clamped as shown, one resting on the other when in use.

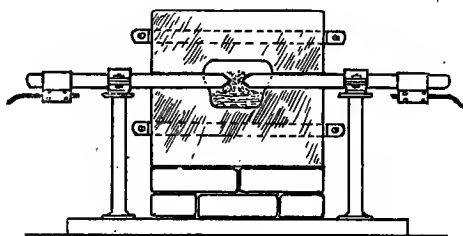


FIG. 2.

The lower block had a hollowed out cavity in the middle to form the crucible, and running to this from each end was a groove to receive the carbon pencils or electrodes.

The upper block was also hollowed out a little where it came over the crucible cavity, and it was stated that the intense heat hollowed it out a little more and gave it a glossy polish, a reflecting dome being obtained in this way.

Of equal importance, may be described the furnace first designed and used by Willson. This resembled Fig. 3. A graphite crucible forms the lower cavity, and serves as one electrode.

The vertical carbon rod shown is the other, the ingredients to be acted on being thus brought directly between the two. The connection of the lower electrode is effected by attaching the conducting wire to an iron plate on which the graphite crucible rests. The molten contents of the latter discharge through a tapping-hole.

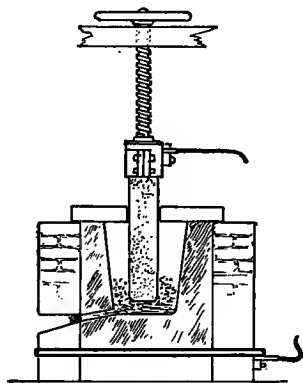


FIG. 3.

This furnace was not suited for producing carbide in bulk, consequently another was designed and used at the Spray Works, this latter being as represented in Fig. 4. This may be described as a furnace in duplicate, being two open furnaces working side by side quite independently, allowing for their alternate use. The walls are of ordinary brickwork, the front open (but partly closed when required by iron doors). The internal dimensions are about 3 feet by 2 feet 6 inches by 8 feet in height. Each furnace opens into a short chimney at top to carry off gases.

The general detail of the small furnace, Fig. 3, is followed, in that the upper electrode is carbon while the lower is formed by pieces of carbon resting on an iron slab. The proportions, however, are on a larger scale, the upper carbon being 3 feet long and 12 inches by 8 inches in thickness, consisting of six 4-inch by 4-inch square rods. The clamp holding the carbons has a 3-inch copper

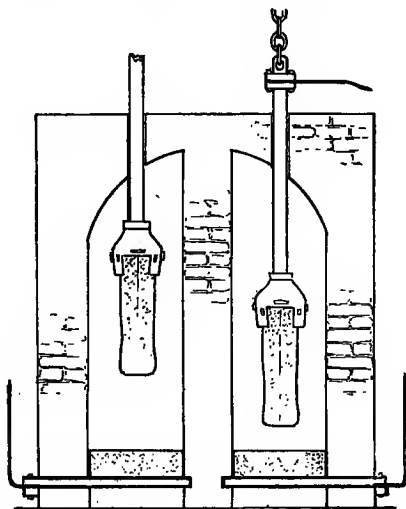


FIG. 4.

rod extending up through the crown of the furnace, where it is connected to a chain passing over pulleys and down to a threaded rod passing through a hand-wheel. By this means the carbon can be raised or lowered as required. The lower electrode—carbon on an iron plate—forms the floor of the furnace chamber.

With this arrangement it is necessary, when the fusion is completed, to withdraw the upper electrode and allow

the carbide to cool into a solid mass or ingot before it can be removed, and the next improvement was to save the time lost in this way. A firm erecting works at Niagara effected the desired end by substituting a crucible on wheels for the fixed carbon and iron base, as shown in Fig. 5. The crucible car is iron, with carbon lining at the bottom. The car is run in and out of the furnace enclosure on a track, so that immediately one charge is properly fused the upper electrode is raised, the car of molten material withdrawn to cool, while a new one is at once run in to be operated on. It will be seen that as the cars are run in some connection must be made to the conducting wire; then it must be broken to allow of the car being run out. The illustration shows the method of doing this.

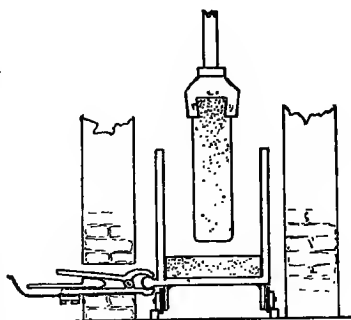


FIG. 5.

A number of improvements were made to facilitate feeding the prepared ingredients into the crucible; to take away the hot gases (which have been found destructive to the clamp and other parts), etc. This arrangement of crucible cars was afterwards adopted by Willson.

Another early furnace was that designed by Bullier, who had been associated with Moissan in his researches. Fig. 6 illustrates this, and it will be seen to consist of a crucible (lined with magnesia) having the upper carbon electrode dropping into it as usual, while the negative electrode is a carbon-lined iron plate, as in previous

examples. The novelty consists in the crucible or melting chamber being raised above the floor to admit of the bottom electrode swinging downwards on a hinged joint, as shown, which precipitates the ingot (when cooled sufficiently to be a solid mass) into a car beneath.

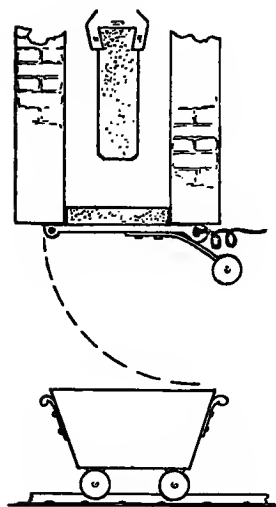


FIG. 6.

In operation the positive carbon was lowered on to the negative plate; then, as the material was fed in and fused, the upper carbon was gradually raised to admit of the new material being acted on as it arrived, without any excess action on the lower part of the mass.

The different types of crucible furnaces, as those just described, are considered too slow in America, and what are known as continuous furnaces are being introduced and used. It is, of course, quickness in output and saving of labour that are sought after, there

being no gain in economy of materials or in quality of the product. The American nation is noted for its labour-saving devices, and mechanical arrangements by which output is so enormously increased. Complication of parts has no terrors for them.

Perhaps the best known continuous carbide producer is Bradley's patent, illustrated in Figs. 7 and 8. Two peculiarities of this furnace are (1) that the core of carbide is made to act as one of the poles or electrodes, and

(2) that resistance due to the mass of carbide is reduced as far as possible by bringing the current near to the arc by means of copper plugs in the rim of the wheel. In the illustrations there is seen a wheel formed in sections

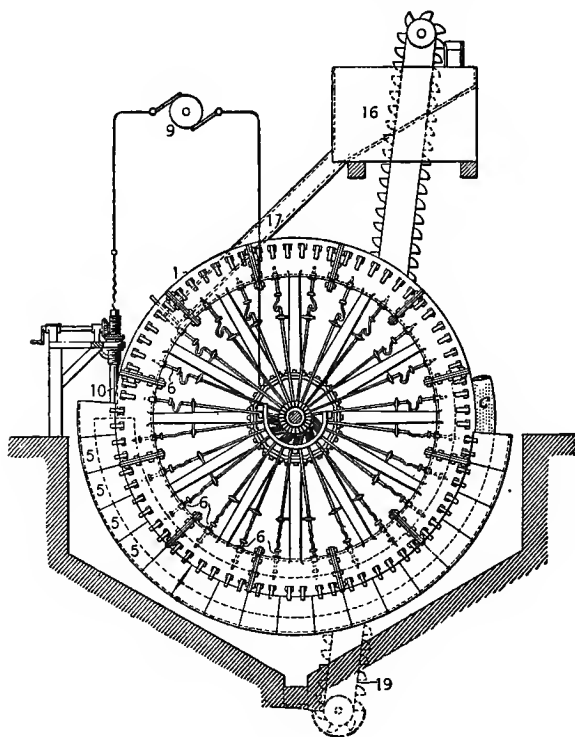


FIG. 7.

bolted together. This wheel may be 15 feet in diameter, and works on its axle 2. The rim of the wheel is concave, as shown, and provided with latches, 3 which are secured on to studs 4, these holding on semicircular plates

or covers of iron 5. This annular rim is about 3 feet in diameter. The copper plugs referred to come at 6, and are connected to a commutator 7 against which comes a brush 8 connected with one pole from the dynamo. The

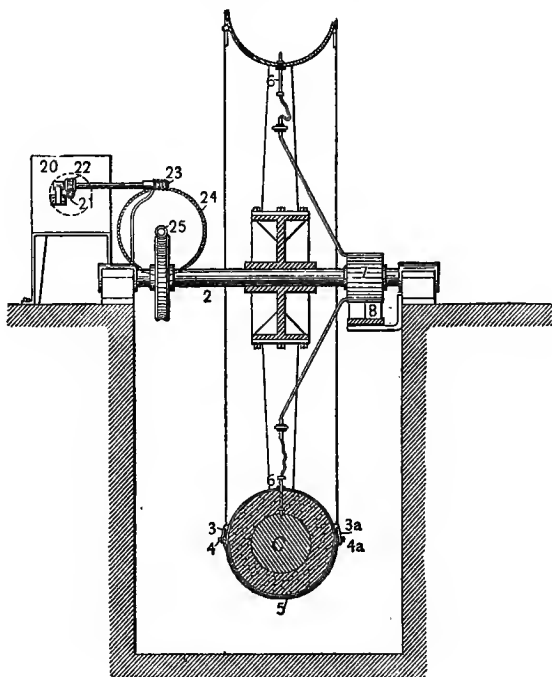


FIG. 8.

other pole is the carbon rod 10 which is held in the gearing above, and by which it can be adjusted. A receptacle for the mixed coke and lime is provided at 16, this having a trough 17 provided with a regulating gate. The chain of buckets 19 is to lift out any spilled material from the

pit, the latter being made with sloping sides to facilitate this. The figures from 20 upwards represent gearing connected with an electric motor, by which means the whole apparatus is made to rotate. A very slow speed is all that is necessary, five days being probably allowed for one complete revolution.

In operation, the chamber in which is the carbon electrode first has its circular outer piece fastened on; then the mixed ingredients are run down into it until the carbon electrode is quite covered. The current is next turned on and the motor set to work. As the charge slowly draws away from the electrode the material first fuses and then cools; and as the movement of the wheel progresses it carries away a solid core of carbide surrounded by some uncombined material. As fast as is necessary fresh circular plates are added, and the supply of new material is regulated to keep the carbon continually covered. When the wheel has turned sufficiently to bring its closed part up on the other side, the outer cover plates are taken off and the carbide removed as fast as it arrives. In removing the carbide, whatever uncombined material remains around it falls into the pit and is removed by the chain of buckets. Solid carbide of calcium is a conductor of electricity, and in connection with the copper plugs serves as one of the electrodes. The parts marked C represent the solid core of carbide.

The Foyers furnaces are not continuous, being of the Willson type previously explained, but with several improvements which are the result of experience. The crucibles are trucks running on rails, but these trucks have their ends made up of slips or sections with regulating openings in them to allow of carbonic oxide being

discharged. The resulting carbide is a rough ingot surrounded by uncombined material.

On the Continent another type of furnace is used, which may be considered as continuous, although it is a totally different system to that employed in America. These are known as "running" furnaces, since the carbide, when in a liquid state, is "tapped" or "run" from a hole at the base of the crucible, in the same manner as molten iron is run from the base of a cupola. The carbide is run into troughs or moulds, and when cold, becomes moulded like ingots.

Probably the furnace designed by Dr. Rathenau is as much used as any, and Fig. 9 will serve to describe its working. It consists of what may be considered as a

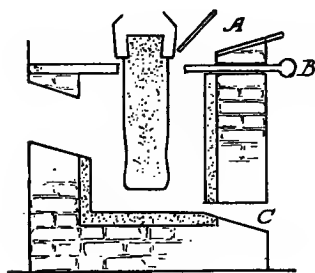


FIG. 9.

crucible, this being a square space into which the mixed ingredients are put, and down into which the upper carbon electrode comes. At A there is a shoot into which the material is fed, and the supply is stopped or regulated at pleasure by a sliding plate or damper at B. The operator first fills the furnace with mate-

rial through the shoot A, then, when a proper time has elapsed, the resulting carbide is "run" from the tapping-hole C. The gases escape from an opening at the rear of the furnace, and every care is taken to exclude the air. By these precautions the life of the carbon electrode is considerably prolonged.

Various properties of carbide of calcium in rela-

tion to its manufacture and use.—It may be at once explained that carbide of calcium is a perfectly harmless material if kept quite dry. It may be pulverised or receive other violent treatment, or it may be subjected to fire heat of any fierceness without particular injury, and quite without developing dangerous qualities. Only when subjected to moisture are there dangerous conditions; but even then it is not the carbide but the gas evolved from it that has to be considered, and the care needed is only that which coal gas requires to make its presence and its use quite safe to those dealing with it.

The materials used in the manufacture of calcium carbide are calcium oxide and carbon, or in common language quicklime and coke (one of the several forms in which we have carbon). The ordinary lime of commerce is not quite suitable because of the impurities in it, and the same remark applies to gas coke. When carbide was first made on a commercial scale no particular care was used, with the result that some of the impurities in the carbide, and in the gas, not only proved troublesome but were, in some instances, a source of danger. The chief annoyance was a haze in the rooms where the gas was burned, whilst the danger was in the existence of a spontaneously inflammable gas due to the presence of phosphorus in some form. In addition to these troubles, any impurities in the ingredients used caused the carbide to be impure and unreliable generally.

The lime now used is very carefully selected, with the view to using only that which is free from such impurities as phosphates, sulphates, magnesium, aluminium and silica, and the burning is done in gas kilns to prevent the fuel affecting the resulting lime. Mountain limestone is usually the purest, sometimes having 99 per cent. of

pure material, with its small margin of impurities containing no phosphates. It is phosphorus, of all things, that has most to be avoided.

The carbon used is generally coke, as stated, but it is possible to use anthracite and charcoal. A pure quality of anthracite answers well, but charcoal often contains a troublesome quantity of phosphates and is not very easy to use.

Coke is the material mostly used, and this has to be specially prepared. Coke is, of course, ordinary bituminous coal with its gaseous and tarry ingredients carried off. Attempts have been made to use the coal unconverted, but in the carbide furnace it was found that the tarry nature of the coal caused it to fuse into a troublesome mass, while the hydrogen gas given off was liable to explode unless very carefully dealt with. For these and general reasons the bitumen and hydrogen are eliminated before coal is used for carbide making. Anthracite, as is known, is a coal possessing only an exceedingly small percentage of hydrogen, this being the reason why it is flameless in burning.

The coke used for carbide making is a good quality foundry or furnace coke. This is prepared from a moderately bituminous coal, which is coked in specially prepared ovens. The coal, however, is first crushed fine, screened and then washed, after which it goes into the coke ovens well freed from earthy impurities, such as sulphur, etc. There still remain, however, traces of sulphur in the finished coke, but not sufficient to be a source of trouble.

The proportions of lime and carbon generally used in the manufacture of calcium carbide are 100 of lime to 68 or 70 of carbon, and both ingredients are ground to

a fine powder for the ingot process like Willson's and the continuous furnaces used in America. In the furnaces used for "run" carbide the materials are only reduced to grains, i.e. granulated; and there are hopes that this will be found sufficient for all purposes, as the advantages are many. The fine grinding is, of course, more expensive than granulating, but what is worse, the volume of gases given off during the conversion of the ingredients to carbide in the furnace tend to blow out some of the finer and lighter material, and this is often sufficient to make the proportions of the two incorrect. Moreover, this fine material discharged into the factory has a deleterious effect on the health of the workpeople, and is injurious to machinery.

The makers of ordinary ingot carbide (as at Foyers) and those producing "run" carbide have arguments to show how each is superior to the other. The process adopted by the former yields an ingot that looks like a very rough and irregular mass of coke; the rough, irregular exterior being due to the ingot having a crust of partially converted material. When this ingot is cold it is simply broken up, and either hand-picked or screened to various sizes and then put in drums for delivery. In the breaking and picking the crust has to be discarded as far as possible, as its gas-yielding properties are not to be relied on; but it follows that, although care is used, some indifferent pieces must get into the drums with the good material, and this is made much of by those believing in "run" carbide. There is, however, little in this argument, as the Foyers works guarantee their carbide to yield from 4.8 to 5.2 cubic feet of gas per pound, and little fault can be found with this.

As opposed to the "run" carbide, although there is

no useless or semi-useless crust to the moulded ingots, it is stated on the best authority that to get the carbide to "run" freely it has to be reduced to a more liquid state than the ordinary ingot process, and to ensure this without attaining a temperature injurious to the furnace it is necessary or desirable to use a higher proportion of lime. The result is a carbide of a less gas-producing quality.

In the manufacture of carbide it is essential that some provision be made to convey away the gas evolved in the furnace. This gas is carbonic oxide, which is highly poisonous, and gives no warning when doing its ill work. The works cannot be open-roofed or roofless because of the rain, it being recognised that considerable waste of carbide would ensue if it got wet, or even if produced and handled in a wet, damp place. The acetylene evolved, too, would be a source of danger, therefore carbide manufactories must be sound and dry. This being the case, there must be efficient ventilation. There ought to be chimneys or flues from the furnaces themselves with ventilating arrangements generally to free the place of any gases escaping into it.

It is found that 1·80 ton of lime and coke mixture will yield one ton of carbide. The size to which the ingot is broken is from 4-inch lumps down to fine grains. For large generators the large carbide is suitable, whilst the very small is suited for cycle lamps, etc. There is no loss nor gain in using carbide broken to large or to small pieces: it is simply the question of which suits the purpose to which it is to be put.

The storing of carbide is regulated by legislation, being included in the Petroleum Acts, and it is necessary to procure and have a licence to store any but a small

quantity. No licence is needed and no rules have to be followed in regard to storing any quantity of carbide up to and including 5 lb., provided it is stored in hermetically closed metal vessels holding not more than 1 lb. each. In other words, the total quantity must not exceed 5 lb., and this must be in tins holding 1 lb. each or less. This rule is to allow of carbide being used for cycle and other small lamps without the necessity of a licence.

For quantities exceeding this, for ordinary house-lighting purposes, the carbide is put up in drums holding about one hundredweight each; for these a licence is needed, and certain rules must be observed to secure the licence and retain it. The licence is issued by the local authorities, and the Act orders that a sum not exceeding five shillings may be charged for it, any sum below the above being at the discretion of the authorities. It must be renewed each year.

The issue of a licence imposes certain conditions : (1) For ordinary lighting purposes the licence is for carbide used on the premises and not sold by the person storing it. (2) That it shall be in proper drums. (3) That the place of storage be approved by the surveyor; that the place be not used to store anything else; that it is not in or beneath a dwelling house. (4) That the store shall not be altered in any way after the granting of the licence, unless the surveyor be apprised and approve of it. (5) That each drum hold only 112 lb., and that only one be opened at a time. (6) That every drum or vessel holding more than 2 lb. be kept locked up. (7) That every drum or vessel be labelled "Carbide of Calcium," "Dangerous if not kept Dry," in bold lettering, with the following caution : "The contents of this

package are liable, if brought into contact with moisture, to give off a highly inflammable gas." In addition, it is required that owner's or sender's (vendor's) name and address be on the label.

These rules make no mention of how to keep the opened drum of carbide. Many generators for lighting country houses of moderate size, and where the gas is economically used, do not dispose of more than 3 lb. of carbide per day during spring and autumn, which means that an ordinary drum may remain open more than a month before all its contents are used. Calcium carbide is so susceptible to moisture that the little water there is in the air even on a dry day will cause gas to be generated and given off with some freedom. On a damp day the generation is pronounced. This causes great waste, odour, and conditions which the Act would consider dangerous.

The drums at first used in England had screw tops, which could be replaced and made air-tight with putty, although it was an irritating job, but now the drums are opened in a way that admits of no re-closing ; and what is to be strongly recommended is that the drum, when first opened, be emptied into a vessel of some kind with a lid which can be secured air-tight. Without this there must be a very real waste and an explosive mixture in the store.

Of course no artificial lights are ever taken to the carbide store, but this is no reason why there should be gas going to waste there. The store should have a bold label on the outside of the door, stating that no lights are allowed ; and, as already mentioned, the door must be kept locked.

CHAPTER II.

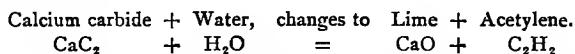
ACETYLENE (C_2H_2).

THIS gas is produced by subjecting certain carbides to the action of water. Its original discovery was made by Professor E. Davy in 1836, when, in attempting to procure potassium he obtained a substance which decomposed in water and yielded a gas found to be a new kind of carburetted hydrogen. He thoroughly investigated its qualities and properties, established its chemical formula, and gave his opinion that it was a gas possessing a good commercial future if the material which yielded it could be made cheap enough. The material which this scientist discovered, and which yielded the gas, was potassium carbide.

Since that early date many other means of producing acetylene have been discovered and experimented on, and doubtless all have contributed much valuable aid to science. It was not, however, until 1892 that acetylene became commercially possible, and this was due to experiments made by Thomas L. Willson, a Canadian, at his works at Spray, N.C., America. In this year Professor H. Moissan also made practically the same discovery as Willson, but his experiments were purely scientific and his results were not immediately put to the commercial use to which Willson put his. The best authorities state that priority rests with Willson, though

they willingly give Moissan all the credit that is due to him. The discovery made by these two men was, as explained in Chapter I., that lime and carbon could be made to combine in the electric furnace, and produce a carbide that would yield acetylene at a comparatively low price.

When calcium carbide and water are brought into contact with each other a reaction or change occurs as follows :—



The above expresses what may be termed the theoretical reaction. It will be noted that the product besides acetylene is oxide of calcium or quicklime, which would be correct if only the precise amount of water needed was or could be used. In practice there is an excess of water, and hydrate of lime or slaked lime is the waste material found in the generator. It will also be noted that the acetylene is formed by the union of the carbon from the carbide with the hydrogen from the water, the lime of the carbide and the oxygen of the water being separated and leaving this new compound free.

At first the carbide was made with lime and coke not specially prepared in any way, and in consequence the resulting gas was heavily charged with impurities. Some of the impurities proved to be possessed of dangerous qualities, whilst others caused annoyance in one or more ways. It was quite thought at first that practically any quality of lime and coke could be used, and much was said about producing carbide at about 3*l.* per ton ; but a few disagreeable experiences changed this. The carbide as now made at Foyers is guaranteed to yield a

gas free from impurities in dangerous quantities, and no hesitation need be felt in using it. It is satisfactory to know that the lighting engineer's troubles are not increased by having to combat the risks of dangerous impurities in the gas.

Under these circumstances the only care that has to be exercised is in properly dealing with the small margin of impurities which are present, and which cause annoying results when the gas is consumed. It is practically impossible to obtain absolutely pure lime and carbon for the production of carbide in large quantities, consequently the acetylene always has phosphuretted hydrogen, sulphuretted hydrogen and ammonia present. As just stated, any dangerous proportions are no longer yielded, but those that exist make themselves very disagreeable.* The chief cause of the haze sometimes experienced in rooms where unpurified acetylene is burned is the phosphoretted hydrogen. This gas is absorbed by the water-vapour in the air of the room, and this makes its presence noticeable to a much greater degree than it would were the combination not to occur. As the air of occupied rooms is always humid, the conditions are favourable to the occurrence of the trouble. Purification (simply provided) removes this objectionable gas (*see* Chapter V., page 143).

The sulphuretted hydrogen is a desirable impurity in one sense, for it is this which gives the pungent odour to acetylene and makes an escape quickly discernible. It, however, bears reducing by the purifier (which does not leave the gas odourless), as it is absorbed by the vapour in the air of the room, and takes the character of sulphurous acid, which latter, when condensed on cold

* Purifiers and purification are dealt with in Chapter V., page 143.

surfaces, will bring about a slight corrosive action on any substances which are susceptible to it.

The ammonia in unpurified acetylene, with the presence of moisture, attacks metals and makes explosive compounds. It is particularly in conjunction with copper that the presence of ammonia is to be feared: consequently the rule is never to let copper appear in any part of an acetylene apparatus—nowhere, from the generator to the burners. This impurity, ammonia, is chiefly removed by washing the gas, and it is desirable that every generating apparatus should have provision for passing the gas through water, between the generating chamber and the gas holder, and before it enters the purifier. There are other impurities (condensable vapours) which are removed by this means, and the gas is cooled at the same time.

When the carbide is decomposed in the generating chamber there is a rather large amount of latent heat liberated. In the manufacture of the carbide there is considerable heat absorbed and held latent, and it is therefore known as an endothermic compound. This heat is liberated when the carbide is decomposed, and unless the generator (meaning that part of the apparatus where the carbide and water meet) is suitably constructed the heat will set up secondary reactions, with a loss of carbide and probably something worse. Such substances as certain liquid hydrocarbons and similar compounds are formed, and these exist at the expense of the acetylene, besides giving trouble. The chief care in generator construction is therefore to ensure cool generation, for in this lies the chief source of efficiency and economy. Briefly, this is obtained quite easily by providing a sufficiency of water to the generating chamber (an insufficiency having been

fatal to many "systems" of generation), and immediately the gas is made by passing it through water to cool and cleanse it. It is, however, quite possible to use too much water, for this liquid absorbs acetylene in a sufficiently large volume to be wasteful if care is not used. This is fully explained in the chapter on generation (see page 50), but it may be said here that if the water used for cooling the made gas can be caused to come to the generating chamber to make more gas, the loss by absorption then becomes an unimportant quantity.

It is, of course, understood that acetylene, like coal gas, is not combustible by itself, but (when used in the ordinary way) only burns if mixed with the oxygen of the atmosphere. Consequently, acetylene requires about the same conditions for burning, or for bringing about an explosion, as coal gas. The only way in which acetylene can be considered as more dangerous than coal gas is that it has a wider range of explosibility. Professor Lewes has determined the limiting percentages in air as follows:—

Acetylene	3 to 82
Hydrogen	5 to 72

These percentages show that with acetylene it only requires three parts in a hundred of air to make a mixture that will ignite; and on the other hand, if the air percentage is only 18, with 82 parts of acetylene, ignition is also possible. H. Gerdes in some carefully conducted experiments, has shown what degree of explosive force is experienced with acetylene and air mixed in various proportions, and his table is as follows:—

PRESSURES OBTAINED BY EXPLODING MIXTURES OF
ACETYLENE AND AIR.

Percentage of Acetylene.	Pressure in Atmospheres.	Percentage of Acetylene.	Pressure in Atmospheres.
2'5	0'05	11'1	11'1
3'7	3'7	12'5	10'6
4'7	4'9	16'6	7'2
5'5	5'2	20'0	16'0
6'6	6'8	25'0	16'9
7'7	8'2	33'0	18'4
8'3	8'6	50'0	20'3
9'1	9'7	66'0	10'0
10'0	11'1	80'0	6'3

From this it will be seen that the effect when the acetylene is at its smallest and its largest volumes would not create what we recognise as an explosion, if ignited ; but when the proportions are half acetylene and half air an explosion of full violence occurs.

These results prove nothing to the disadvantage of acetylene ; they only go to show that at least the same care must be exercised to prevent an escape as with coal gas. No greater precautions are requisite in this respect.* No gas which is explosive in air should ever be allowed to escape in sufficient volume to bring about an explosion in even a small cellar or room. If such heedlessness is allowed, and it is added to by taking a naked light to the place, an explosion must be expected.

There is only one aspect of this question that deserves particular consideration, this being the possibility of air getting into the generating chambers when they are charged, or the existence of air in the gas holder when it

* The chief reason why extra care is needed to prevent leakage of acetylene is that, volume for volume, acetylene is so many times more expensive than coal gas.

is first charged, or if it is opened at later periods. When an apparatus is newly erected and first charged, it is much the better plan to remove a burner at a convenient point, then open the tap and let the first few feet of gas and air escape without ignition. This must of course be done in daylight, and at some point where no naked light will be brought for an hour or two (depending on how the place is ventilated and the freedom with which the gas can get away out of the room to the outer air). There is little doubt that many an apparatus has had an explosive mixture in it when light has been first put to the burners after the work of erection is completed, but that dangerous results have been avoided by two things. The first is that the gas has driven the air before it rather than mix with it ; secondly, and more probably, the extreme smallness of the orifices in the burners have prevented lighting back. There is also the fact that the pressure or speed of outflow of the gas from the burner tips is not favourable to lighting back. The correct thing to do, however, is to cleanse the holder of air when the gas is first made and stored in it. After this air should not have access to it, unless some repairs or attention at any time be needed, and then the air must be disposed of the same as when the holder was first charged.

The generating chambers do not usually have provision for air discharge, it being considered that the volume shut in when the re-charging is done is not sufficient to prove an element of danger. This is correct in a general sense, but it still makes care necessary in designing and in choosing generators. It is certainly desirable that the majority of large generating chambers should have provision for air discharge, for in these the volume of air may be a source of danger ; and it may be

assumed that large generators are attended to by men to whom an extra tap or two would prove no complication. Small generators, under the care of domestic servants and amateur attendants, need to be very simple, and as an air-cock is also a gas-cock when the air is discharged, these taps are best avoided. The best plan with small generators is to have the chambers no larger than is needed for the racbide carrier and the proper quantity of water which follows. This keeps the volume of air enclosed, each time recharging is done, to its narrowest limits.

On burning acetylene in air, under proper conditions for perfect combustion, the products are carbonic acid (CO_2) and water (H_2O), the same as other compounds of hydrogen and carbon when completely consumed. The quantity of oxygen from the air required by one cubic foot of acetylene when perfectly burned, is two-and-a-half cubic feet, and for a given light this is much less than coal gas burned at ordinary burners, though a trifle more than coal gas burned with incandescent mantles. Acetylene also (and consequently) fouls the air less than coal gas burned at ordinary burners, the proportions of carbonic acid for the two being as 1 to 4.5. Acetylene therefore ranks high in the two qualities of not abstracting much oxygen from the air of a room, and not contributing much in the way of objectionable products to it.

Acetylene is also a small heat producer on combustion taking place (as can be judged by the volume of products), the emission of heat from acetylene and from coal gas burned at ordinary burners being as 1 to 8 ; but here again coal gas burned with incandescent mantles scores, as the heat evolved is less than with acetylene, though only a trifle. This is, of course, for a given candle-power of light, not volume of gas.

The lighting power of acetylene is undoubtedly good, and the quality of its rays excellent, but the amount of light to be obtained from a given quantity of gas is very different in practice from what it is in theory. It is as well to realise this, and put the practical lighting value of acetylene on a proper basis, for going on as things are now, there must be endless disappointment.

It is usually considered that a cubic foot of acetylene will give a 50 candle-power light for one hour or very nearly, and theoretically all authorities consider this right. In practice, however, the light given per cubic foot of gas depends on the burner, and, like coal gas, the smaller the burner the less total candle-power it affords for a given volume consumed. A very small burner will not give more than about 10 candle-power for a cubic foot burned, while a larger burner, constructed to afford the best lighting results, will afford as much as 46 candle-power per foot burned. This latter would be from a Bray type of burner, non-atmospheric, which unfortunately carbonises and requires renewal sooner than the Naphey type.

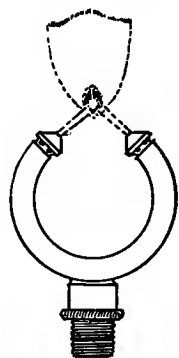


FIG. 10.

The Naphey type of burner is illustrated at Fig 10, consisting, as will be seen, of a pair of arms arranged so that the gas jets impinge on one another and a flat flame results.* All round the tips of the burner are holes pierced, so that the outflow of gas draws air through to

* The flat flame is at right angles to the burner, and the edge only should have been shown in this illustration as a thin line. (See Figs. 57 and 58, page 155.)

intermingle with it (much on the principle of an ejector). This burner is at present one of the most lasting and convenient, and is, perhaps, used more than any other. A variety of burners is described later.

From experiments made, it is found that the favourite half-foot burner, known as a 25 candle-power, only gives about 25 to 28 candle-power per foot of gas. In other words, although it burns half a foot per hour its yield during this period, with this volume of gas, is only about 13 or 14 candle-power. On the other hand, the one-foot Naphey type burner, called a 50 candle-power, gives as much as 35 candle-power per hour.

The unfortunate detail is that the larger and more economical burners cannot be used very successfully, except in the few instances when all larger burners are suitable, or when the large burners and the small ones can be put on separate services with independent governors. To burn acetylene to advantage, the pressure should be suitable for the size of burner or nearly so, and while 20 candle-power and 25 candle-power burners give the best results with two to two-and-a-half inches pressure, a 50 candle-power burner needs a four-inch pressure for best results. If a light pressure be used for a large burner, it will make a dull flame and probably a smoky one, while if a four-inch pressure is used for 25 candle-power burners, it will cause waste of gas and not the best light, unless the bracket tap is turned off a little to check the flow. This latter answers well, but in ordinary domestic use the bracket taps are not regulated with any nicety whatever.

Of course in this latter case acetylene is not served worse than coal gas, with which governors are seldom used (much less than they should be), and the bracket

taps are relied on to save excessive issue, distorted flame and noisy burning. With acetylene, however, some good attempts should be made to burn the gas at a pressure adapted to the burners, and this can only be done by the use of governors, and by either using burners all of about the same candle-power or else grouping the different sizes and putting separate smaller governors to each.

The 20 candle-power and 25 candle-power burners are the sizes mostly used, and, although not so economical as large burners, they are best adapted for residence and similar use. If one or two larger burners are required in an apparatus of small ones, then the best plan, so as to work these at low pressure, is to have double 20 candle-power or double 25 candle-power instead of single 40 candle-power or 50 candle-power burners. These double burners will be seen in a later chapter, and as each flame and the requisite issue of gas is small, the pressure need only be that for small burners, as will be understood. This is not the most economical method so far as light for consumption is concerned; yet in having burners of a nearly uniform size controlled by one governor there is a certainty of getting the best light the burners can give, and no waste (even with careless attention), as the bracket taps need no regulating. In speaking of pressure in its relation to consumption, this pressure is at the brackets or burners, not at the holder or generator. The instrument for ascertaining the pressure will be found illustrated and described later; it can be quite easily made, or can be purchased.

The actinic properties of acetylene are very pronounced, and the light afforded is a near approach to that which we receive from the sun, and therefore some-

what approaches daylight. There is a marked difference to the yellow of coal gas burned from ordinary burners, and the unnatural colour of coal gas burned with a mantle. In the same manner it differs from the two kinds of electric light, incandescent and arc. Its similarity to daylight enables tints and colour compositions to be judged with some correctness. Even pink and blue, and the various sensitive shades obtained by mixing these, from lavender to violet, can be judged satisfactorily.

The temperature of the acetylene flame has been determined by various scientists, and the average of the figures given is 2000° C. This is a little higher than the heat of a coal-gas flame, which is about 150° less. The heat at which ignition occurs, however, is only 480° C., and this admits of the gas being lighted from a brightly glowing cigar or cigarette end.

In regard to the toxic effects of acetylene, the *British Medical Journal* has reported at some length the results of experiments made by Professor Oliver and Dr. Bolam, in which are shown the relative poisonous properties of acetylene as compared with coal gas. From this it appears that coal gas has dangerous properties which acetylene has not, for with the former there is carbonic oxide largely present, and the inhalation of coal gas brings about asphyxia in a very short period owing to this. Carbonic oxide, as most engineers know, is poisonous in the fact that it enters into combination with the blood, from which it cannot be dissociated without great difficulty. Acetylene is minus this gas, and in itself gives no evidence of a distinct poisonous effect. The report states that an animal, a rabbit for example, placed in a bell jar, experiences very little inconvenience when a mixture of acetylene and ordinary air is pumped in.

Only when air is excluded and nothing but acetylene admitted do symptoms gradually and slowly develop.

This showed that while oxygen is in the medium breathed, that and that only is absorbed by the blood, and very little acetylene. After a more lengthened exposure to acetylene than that which is necessary with coal gas the animal becomes intoxicated, and falls over on its side apparently profoundly asleep; and while all through the experiment the breathing is somewhat short and rapid, stupor steals over the animal apparently without pain. No nervous or respiratory excitement is exhibited such as may be seen in ordinary asphyxia. Where this sleep has been induced and not carried too far, the rabbit, when removed from the bell jar and allowed to breathe atmospheric air, recovers in a few seconds, and shows no weakness nor paralysis nor other ill effects. Briefly, a few breaths of ordinary air restore it to the condition it was in at first. If the experiment is carried further and the animal has been deeply asphyxiated, death may ensue, or recovery, if obtained, is very difficult.

The conclusion drawn from this is that the danger to life from breathing acetylene appears to be less than it would be with coal gas, and the prospect of recovery greater when the subject is brought into the open air, away from the gas-laden atmosphere.

The price of the gas is a subject that has had some doubtful treatment at the hands of generator makers, who, for obvious reasons, have grasped at and advertised theoretical figures which the most perfect means of generation could never confirm in practice. Then, again, generator makers, once a figure is stated, must hesitate about giving a higher cost, as such an admission would

be damaging to their apparatus in comparison with others. Acetylene cannot compare in price with coal gas when the requirements are large enough to warrant laying down a good sized coal-gas plant. This would be for a small town or large village. For small villages the conditions are quite different, as it will be found that unless the demand is fairly large coal gas cannot be produced with profit under about 7s. per thousand cubic feet. Then acetylene can be a distinctly strong rival, for it is possible to produce this at a cost which, light for light, is equivalent to coal gas * at 3s. 6d. per thousand at the generator, or say 30 per cent. more at the burners, to allow for loss, wear and tear, and interest on outlay. The plant or "gas works" for acetylene is a small and inexpensive affair compared to coal gas. There is not the least doubt that for village lighting acetylene is practicable in every way.

For residence work in the country, for farms, factories and the like, where coal gas is not obtainable at all, acetylene is not only practical in cost, and generally, but is really a boon. With a good type of generator the attendance can be unskilled, and occupying as it does less than fifteen minutes per day, the cost is nothing, or at least should not exceed one shilling per week. This is because the attendant need not be engaged expressly for this work, but may be a farm hand, an estate man, a footman, or even a female domestic servant in some cases. This compares well with an electric plant, which needs an engineer. His time is nearly all occupied, and therefore the cost of electric light, even when power is got for nothing (from a

* Burned with ordinary flat-flame burners.

waterfall), comes out at about the same as acetylene after paying for carbide and attendance. In other words, the amount of attention needed by an electric plant will cost at least twelve shillings per week for labour, supposing the man fills up his time doing something else ; while this amount will pay for attendance and carbide for an acetylene plant of fair size. The wear and tear and general upkeep of an electric plant is of course very much greater than with acetylene.

The dangers of acetylene are comparatively few and easily guarded against. When the carbide supplied was less pure than it is now, there were risks of gases being developed which were self-inflammatory, but nothing more need be said about this, as the carbide now obtainable in England is without this alarming quality.

At first it was thought that acetylene would combine with various ordinary commercial metals and produce explosive compounds, but experiments conducted by several independent scientists show that acetylene itself is almost inert in this respect ; though in the presence of ammonia and moisture combination does occur, particularly with copper. This forms an acetylide which, in a dry state, is explosive. The remedy is cool and perfect generation of the gas, and its subsequent washing and purification. As previously stated, acetylene should always be made to pass through water immediately it is generated, and afterwards pass through a purifying vessel before it enters the house mains.

Of the effects on the human system when the gas is inhaled, reliable data have been given on pages 40 and 41, and it now remains to say something about the alarming reports of explosions and disastrous happenings attributed to acetylene, and which have so prejudiced its use.

A careful perusal of the various accidents brought to notice has without exception shown the accident to be due to a complete disregard of ordinary precautions. In practically every case the trouble has been brought about by taking a light to the place where a leak has previously been discovered by its odour. It is the old experience of people searching for a gas leak with a lighted candle. Nearly every report reads alike, except that the names and localities differ. One exception was that of an experimentalist who knew the properties of the gas, yet was conducting experiments with a lighted cigarette in his mouth !

If a leak is perceived, as it readily can be by the odour, then its precise existence must be sought in daytime ; and instead of using a lighted candle to locate the issue of gas, try instead what soap-suds will do. The application of soapy water with a brush will quickly reveal a leak, if one exist.

There has been no instance coming to the writer's knowledge, of an explosion due to a candle or lamp being taken to a generator house when the re-charging has been forgotten in daytime and is being done (secretly) at night. There may have been instances, but their infrequency says much for the gas and for the generators, for there can be no doubt that surreptitious night charging has been done hundreds of times. Servants of all kinds and both sexes are sure to neglect or forget their duties sometimes.

A remarkable test of the behaviour of carbide and acetylene under accidental circumstances was afforded by the great fire at Ottawa (Canada). The Dominion Carbide Works were burned out, and when the carbide warehouse burned many looked for an explosion, but

none, of course, occurred. Later on, when the water delivered by the firemen had collected about a foot deep in the basement, the floors gave way and some tons of carbide dropped through. This had been packed in cases, but many broke, and there existed an ideal state of things to cause an explosion. Acetylene was generated in immense volumes, but it merely burned with a low, steady flame; and when after a day or two the water was used up or dried out, much of the carbide was found to be unaffected, and this was packed up again. Some drums were also found quite intact and the contents marketable. The insurance agents investigated this, with the result that carbide was afterwards not considered as a dangerous fire risk.

A fair proportion of the accidents that have occurred cannot be correctly attributed to acetylene in the ordinary way. Considerable stir was made in New York over what was called a disastrous accident due to an explosion of acetylene. In this case it was liquid acetylene (which is not allowed in England), and a man brought it about by improperly using an electric soldering iron on the tank containing the liquefied gas.

The sizes of pipes necessary for the main and branch services of an acetylene apparatus vary with the pressure. For ordinary domestic purposes the 25 candle-power burner, or a size very near this, is customary, and for which a $2\frac{1}{2}$ -inch pressure gives good results. If the apparatus is used for some trade purpose and 50 candle-power burners are fitted, then a 4-inch pressure is required, and a little smaller gas service pipe would suffice for a given candle-power of illumination. Notwithstanding this, it is not desirable to use pipes of the smallest possible size, and a liberal margin in this re-

spect is strongly recommended. The following table includes this margin and is quite reliable. If the number of lights do not agree with those shown, then the sizes of pipes given will even bear a moderate addition to the number of burners. As an instance, a 1-inch pipe might be given eighty lights if absolutely necessary. This is an increase of 15 per cent., and the other sizes will also bear this if really requisite, and supposing the length of pipe does not exceed the lengths given.

SIZES OF MAIN AND BRANCH SERVICE PIPES FOR
ACETYLENE GAS.

Number of 25 c.-p. burners, or equivalent of other sizes, to burn at 2½-inch or higher pressure at the burner.	Distance from generating apparatus, if a main pipe; or distance from main pipe, if a branch.	Sizes of pipes.
2	15 feet	$\frac{1}{8}$ -inch
5	30 "	$\frac{1}{4}$ "
10	40 "	$\frac{3}{8}$ "
20	50 "	$\frac{1}{2}$ "
50	100 "	$\frac{3}{4}$ "
70	130 "	1 "
100	150 "	1½ "
150	180 "	1½ "
270	250 "	2 "

This table would require modifying for village lighting, for although the small branches would be correct for street lamp and for house work, the mains would undoubtedly run to greater lengths than here given. To overcome the resistance of long mains the sizes in the table need not be increased for the number of lights

given, but the pressure at the holder (at the generating house) would have to be increased. There is always some difference between the pressure of the gas at the holder and the burner (without considering any difference effected by the governor, if one is fixed), even with the comparatively short pipes of private installations; but with the long piping of a public supply the pressure at the holder must be increased to ensure a sufficient out-flow at the most distant burners, without considering what effect this will have on the burners nearer to the works.

These conditions, however, would be no worse than exist with every public supply of coal gas. It is practically impossible to give every burner the precise pressure it requires (when the distance and the demand vary so much), and the users must therefore be left to either put governors in their house services, near the meters, or else rely on regulating the bracket taps. The only fault of a higher pressure than necessary (no governor being used and the bracket taps turned full on) is that a slightly less light is given with a greater consumption of gas.

The flame is giving its best light with the minimum of gas, when it is at its full size yet very still and silent, looking like a flame made of a brilliant wax. It is then so motionless and quiet as to appear artificial.

A very comprehensive table of sizes for pipes, house and street lighting, compiled by Mr. Charles Bingham, was published in "*Acetylight*." This is given below.

"Sizes of pipes for acetylene:—The table is based on the specific gravity of acetylene being 0.9 compared with, say, 0.4 for coal gas; and that the friction co-efficient is, according to Ortloff, 0.000139 as against 0.0003 for coal gas; and lastly, allowing for a loss

FOR HOUSE LIGHTING.

Length of the Piping up to	A tube having a clear diameter of							
	$\frac{1}{4}$ "	$\frac{3}{8}$ "	$\frac{1}{2}$ "	$\frac{3}{4}$ "	1"	1 $\frac{1}{4}$ "	1 $\frac{1}{2}$ "	2"
	will feed the following number of 20-litre (0·7 foot) burners :—							
16 feet	8	29	56	166	320	538	940	1642
33 "	5	20	40	117	226	380	664	1160
66 "	4	15	28	83	160	269	470	821
100 "	3	12	23	68	131	220	384	670
165 "	2	9	17	53	101	170	297	519
400 "	1	6	11	34	65	110	191	335

FOR STREET LIGHTING.

Length of the piping up to	A tube having a clear diameter of							
	1 $\frac{5}{8}$ "	2"	2 $\frac{1}{2}$ "	3 $\frac{1}{4}$ "	4"	5"	6"	
	will feed the following number of 20-litre (0·7 foot) burners :—							
33 feet	664	1160	1831	3758	6565	11468	18091	
66 "	470	821	1295	2658	4644	8112	12797	
100 "	384	670	1057	2170	3790	6620	10443	
175 "	297	518	818	1681	2937	5130	8093	
330 "	210	367	579	1189	2077	3628	5723	
660 "	148	259	409	840	1468	2565	4046	
1000 "	120	212	334	686	1199	2094	3304	
1320 "	105	183	289	594	1038	1914	2861	
1650 "	94	164	259	531	929	1623	2560	
2640 "	74	129	205	420	734	1284	2025	
3300 "	66	116	183	376	656	1147	1809	
6600 "	47	82	130	266	464	811	1280	

of pressure of 0.4 inch. The figures were originally metric, which accounts for 1 $\frac{5}{8}$ -inch appearing as the smallest street main: 1 $\frac{1}{2}$ -inch might be used with proportionate reduction in the number of burners. This is the smallest size for street mains."

CHAPTER III.

ACETYLENE GENERATION.

The Principles of Acetylene Gas generation.—The generation of acetylene from carbide of calcium is perhaps one of the most simple processes we have in chemistry (for it needs no more than to bring some carbide and water together), yet it has resulted in an almost endless variety of generating apparatus, and there is some special end achieved (or supposed to be achieved) in every one of them. It is also found that, simple as the process is, there are results that should be obtained and require some special detail in construction to obtain; while, on the other hand, there have been discovered several results that have to be avoided by all means in the engineer's power. Between these two extremes are many things needing consideration to ensure either economy or efficiency, and not least important, there is that excellent feature simplicity to be obtained. At present the most simple apparatus has the most favour even at the expense of economy, and this may be the case for many years to come.

Before describing any of the methods or systems embraced by the generators made, it will be best to describe the actions that occur or may occur when the carbide and water come together under different conditions. The principles of the generators will then be more clearly seen.

There are practically four methods by which acetylene is now generated from carbide. First, that in which the carbide is dropped into water, the water being in sufficient volume to be much in excess of that required for the mere production of the gas. Second, that in which the carbide is placed in trays or chambers and the water allowed to drip on to it as required, in which case the carbide is in excess all the time until the moment when it is nearly exhausted. Third, that in which the carbide is put in a holder or holders and dipped into the water, or has the water approach it for a few seconds, whenever the store of gas gets low. In this the carbide is in excess until it is on point of exhaustion. Fourth, that in which the carbide is placed in holders or trays and the water allowed to flow to it (not on it) and in about sufficient volume for the quantity of carbide attacked by it. There are modifications of all these methods.

The Carbide to Water Method.

Theoretically this, the first of the methods, is the best one, for not only is the heat of generation kept down to its lowest limits, but it is scarcely perceivable owing to its being absorbed by the bulk of water. Added to this is the fact that the gas, as made, cannot get away to the holder without bubbling through water, which cools it and washes out those impurities which are susceptible to water. Over-heating, and the various faults due to it (to be explained directly), are avoided, while the gas passing over to the holder is cool, clean, and only needs chemical purification.

It will be understood that this type of generator, whether automatic or otherwise, consists of a tank of

water with convenience for dropping carbide into it, either in small quantities as required, or more quickly in greater bulk. In the former case the gas holder need only be of suitable size to store the gas evolved by the small charge of carbide as delivered, while the latter must have a larger holder to accommodate the greater volume of gas which is made at once. This difference really amounts to automatic and non-automatic generation, for in automatic generators of this particular type small quantities of carbide are delivered at intervals that correspond with the volume of gas used; whereas the non-automatic have the full charge for the day fed in by hand at once, and the holder must be large enough to take the day's supply of gas in one volume, and not in instalments as the gas is withdrawn.

Having shown the advantageous features of this plan of generation, usually called the "carbide to water" system, some attention must be given to its faults. In the first place it may be considered as being uneconomical in yield of gas. Water is capable of dissolving acetylene somewhat freely, and when opportunity is afforded it on so perfect a scale as this, quite a considerable percentage of the gas coming from the carbide fails to get into the holder. In other words, while there are generators of other kinds, capable of sending 5 feet of gas into the holder for each pound of carbide used, the type of generator now in question seldom gives more than 4 to $4\frac{1}{4}$ feet per pound.

This loss might be reduced if it were possible to use the same water over and over again, but this is not possible for several reasons. One is that the sludge has to be abstracted, and the method of doing this is to run it out of a sludge cock at the bottom of the chamber, and in

doing this some good proportion of the water must go also. If the sludge is allowed to remain, then new carbide dropping on to it does not decompose under the same conditions as when it is surrounded by water. It will instead create local heat sufficient to cause polymerisation (with loss of gas and very ill results, as is explained with the "drip" system), this heat having been known to rise sufficiently, under these conditions, to melt zinc. Instances also occur of lumps of carbide sinking into the sludge, developing great heat and forming a damp-proof case to themselves, so that on cleaning out there are unaccountable pieces of material discovered which may be wrongfully condemned as bad quality, or not carbide at all, because of their not being decomposed.

Attempts have been made to obviate this result by introducing a grid or strainer near the bottom of the chamber or tank, this receiving the new carbide and allowing the sludge to drop through as the carbide is decomposed. It would, however, appear difficult to devise a grid of a suitable size to prevent small carbide going through, yet being open enough for the sludge to fall through freely. Using large carbide (which is possible with a hand-fed apparatus) is not a remedy, as it breaks up on contact with water in the same way as quicklime does when slaked. It would appear best, therefore, to flush out the sludge daily, and be content to let some water go with it.

There is a good reason, too, for changing the water, or some of it, periodically, for the water must get very foul; and it may be supposed that, if left long enough, it might be capable of adding to the impurity of the gas bubbling through it, rather than acting as a cleansing agent. In addition to this, it is important to remember that water

well impregnated with acetylene and its impurities is an element of danger. As will be shown presently, it is possible to arrange that the water which acts as a condensing and washing agent shall also be the water which decomposes the carbide, but in a different manner, and involving practically no loss of gas and no inconvenience or danger from the accumulation of impurities.

The "Drip" System.

This may be considered as the exact reverse to the method just described. Very little space need be devoted to it, for it is in disfavour, and except for special purposes will probably not be heard of much more. In this the carbide is put into a suitable receptacle in a generating chamber, and as the gas is wanted water is allowed to drip on to the carbide and decompose it. It is essentially the basis of an automatic arrangement, the dripping water being controlled mechanically by gearing, or some device operated by the volume of gas in its holder or storage vessel. It is not to be said that the dripping of water on to carbide must be wholly condemned, for in an apparatus of very small size like a cycle or hand lamp the faults of the system are not developed to such a great extent as with apparatus supplying a number of lights. Other systems are found to give much the best results, and the dripping arrangement falls in the rear.

In allowing water to fall upon a heap or a pan filled with carbide, either in drips, in a thin stream or sprayed on, a great heat is quickly developed, and this increases for about half an hour, depending of course upon the quantity of water, the way it covers the mass, and the thickness of the mass. Decomposition of the surface

carbide occurs, and the sludge quickly coats the partially moistened mass beneath, with the result that the very worst conditions are or may be obtained both in heat and gas production. Such a temperature as 1450° Fahr., and even higher, is sometimes obtained, a heat far above that necessary to melt lead or zinc, so that the latter material (also solder) would not remain sound many minutes. As small and inexpensive generators are sometimes made of zinc the result of these conditions needs no further description.

The likelihood of the generating chamber melting is easily obviated by using iron, but this does not alter nor minimise the chief fault of the heat manifested with the drip principle. This is the polymerisation of the gas, also the decomposition of the impurities, and just the possibility of the carbide getting red-hot and firing the gas (this has been found possible). The polymerisation of the acetylene and the decomposition of impurities bring into existence fluids and gases which, if not a source of risk, reduce the illuminating value of the acetylene and prove objectionable generally. There are then usually traces of tar in the sludge, which gives a light brown or a yellowish tinge to it.

One of the products of generation at high temperatures is benzene, and this has the effect of causing the burners to carbonise. There can be little doubt that burners of the Naphey type will not carbonise to the extent to which they often do if the gas is generated under proper conditions, particularly as to the heat evolved. A gas produced and kept at a low temperature (which is easily possible) gives a much longer life to burners than otherwise.

Another fault of the drip system is the difficulty in

controlling "after-generation." This is the decomposition of carbide and generation of gas when the water supply is shut off and no more gas wanted. With a holder of ample capacity the after-generation will not give trouble, but quite commonly the holders are not large enough to take any unusual quantity after the demand ceases, and with many of the small appliances working with a water drip there is no adjustable holder at all. After-generation occurs in most generators of the "contact" type (next to be explained) but not nearly to the extent that it does with the drip kinds. *

The Contact Method.

An apparatus designed for this method of gas production is arranged so that the water comes to the carbide from below. It might in a sense be likened to the drip system, but with the direction of the water reversed (which makes an enormous difference in results) and with the water in greater volume, yet not in such excess as with the "carbide to water" method first described. The "contact" method is having most favour at present, and doubtless always will, for it lends itself readily to automatic generation, and with proper observance of detail in generator construction the good results of the carbide-to-water plan can be obtained while its disadvantages need not accompany them.

There are practically three different plans on which

* There are generators which have water dripping or running in a thin stream into the carbide containers, but so arranged that the water rises to the carbide from below. These do not come within the category of generators that are to be condemned, as will be seen a few pages further on. When the water reaches the carbide from the sides or below, it acts like an apparatus of the "contact" type, and no sludge is formed over the carbide.

contact generators can be built. (1) The carbide chambers, to which the water comes, are stationary, and as the water enters, the resulting gas passes from the chamber over to a holder, the quantity of water being controlled by the holder bell operating a cock as it rises or falls. (2) The carbide chambers are also stationary, and as the water enters and makes the gas, the latter, when in sufficient volume, drives the water back and away from the carbide for the time being. These are generally known as displacement machines. (3) The carbide chambers are attached to the crown of the holder bell, so that when the bell descends it allows the bottom of the carbide chamber to come in contact with the water, with the immediate production of gas and the rising of the bell, which then lifts the carbide away from the water again. As the gas is used so the bell descends, dips the bottom of the carbide in water and rises again. It is a succession of dips until the carbide is exhausted.

With these contact types of generators certain rules must be observed if the best possible results are to be attained. These rules are becoming known, and one or more generators are of a design that embrace them all, while others are less complete in this respect. The rules may be enumerated as follows :

1. It is very desirable that the carbide be divided into rather small quantities, so that the water only operates on handfuls, so to speak, at a time.

2. The water as it enters should be in sufficient volume to flood just that amount of carbide that it touches. This rule is opposed to the principle of the displacement generators, and it is very generally agreed that the water should not leave the carbide after coming to it. To do this introduces some of the faults of the

drip system, as it leaves the carbide with insufficient water most of the time, allowing the carbide to have only a wet surface all the time that the water is driven away. By allowing water to enter in carbide chambers in sufficient quantities, and to remain there, cool generation is effected, with the most economical results.

3. There should be an adjustable gas holder of a size capable of receiving the gas evolved by after-generation (that is, gas given off by the wetted carbide after the gas service-cock is closed), also capable of accommodating all the gas evolved from the carbide in one of the divisions in the chamber. This is to allow for accidental excess of water, or a leaky cock. The holder *must* be provided with an escape pipe, so arranged that if there should be an accidental and excessive over-generation of gas, the escape pipe discharges the surplus when the holder bell has risen to its extreme height. The escape pipe is carried to outside the generator house, so that the gas is discharged into the outer air. Over-generation to this extent should only be possible in cases of gross or malicious neglect, then the worst that happens is the loss of a certain amount of gas.

4. The water of the gas holder may, or may not, be used for generation. It is a matter of opinion. If it is used, then it should be automatically replaced so that its level remains constant. Automatic replacement must involve the use of a ball-valve and cistern, and this being so the water for generation is best taken direct from this without interfering with the water in the gas holder. This water in the holder should be left unused as it does not become objectionably bad smelling. On no account should there be any "working parts" inside the holder which will necessitate taking it apart. The holder should never

require opening, and it is best that it should be so. In the writer's opinion those generators which have the bell of the gas holder carrying the carbide chambers or baskets leave something to be desired. By loading the bell in this way a varying pressure is obtained as the charge of carbide is used. Again, a certain amount of the sludge may fall to the bottom of the holder and have to be cleaned out; lastly, the recharging cannot always be done without admitting a certain amount of air to the holder, and this is undesirable, to say the least.

5. There should be absolutely the least possible amount of gear or working parts to an automatic generator. To speak of complicated parts, is to say the generator is badly designed. Where complication may have been necessary is in attempting to feed the carbide into water in regular charges, but when the full charge of carbide is put in a properly made chamber and the water fed to this as required, then the operating parts can be extremely simple.

6. The gas must not be compressed in any way. It has been officially decided that no apparatus should have the gas in it at a higher pressure than one hundred inches of water. No doubt this is safe, but it would have been better to restrict the pressure to one-fifth of this.* There are generators made which work without gas holders being used to receive the gas as made, and the pressure in these is very high. The use of such generators will doubtless be made illegal very shortly.

7. Provision should be made for the gas to pass through water in its short journey from the generating chamber to the gas holder. Gas made by a well con-

* Even with this lessened pressure, a governor must be put in the house service to act as a pressure-reducer and regulator.

structed contact apparatus is barely warm, yet it carries condensable impurities which are susceptible to water treatment. By passing the gas through water it is quite rid of these, and it is then a comparatively pure gas which passes over to the holder.* It is best not to use the water of the gas holder for it, as the impurities yielded to water make it very impure and ill smelling, and, as previously stated, the holder should not require to be opened or cleaned out. The water chambers or "condensers" for the gas to bubble through are better separate from the holder, and the water must be changed with some frequency, otherwise it may soon become foul enough to add to the impurities of the gas passing through: certainly it would have no cleansing effect. On the other hand, some care must be exercised not to let the water be in volume sufficient to be a cause of loss by gas absorption. The water must be in moderate quantity and only changed when necessary. An ingenious plan embodied in one of the generators in Chapter IV. is to let the water from the condensers be the source of supply to the generating chambers. This amounts to feeding the carbide with impure water, but there is not time for the impurities to seriously foul the water, and, to the writer's own knowledge, whatever they are they have no ill effect. By using this water it will be seen that whatever gas is absorbed in passing through the condensers is given back (or most of it) when the water meets the carbide in the generating chambers. The condensing chambers are kept supplied by a small ball valve cistern.

8. Simplicity in working and attention should be

* The gas then only requires to be passed through a chemical purifier or filter on its way from the holder to the burners.

sought after by every possible means. It does not follow that a complicated apparatus is a bad one, and, in fact, the complexity may be to attain one or more special and good ends. At present, however, the majority of acetylene generators are used for private residence work, and it is expected that an unskilled and youthful (or even female) attendant may be capable of the daily attention, and that no adjusting or repairs be needed that the same attendant cannot effect. It is probable that this state of things will exist for very many years yet, therefore extreme simplicity is necessary not only to make the apparatus understood, but also to make it sell. If a desirable degree of efficiency can be obtained simply it is best, of course, and this brings to attention a detail probably little thought of in generator construction. It is to make the apparatus so simple in working that it can be recharged after dark without a light. It is of no use ignoring the fact that the average attendant is unskilled and forgetful, and there must be very many instances (unknown) of the recharging being forgotten during day-time, and there always will be. There are no reasons why a generator of moderate size should not be recharged in the dark in about five to ten minutes, if it is made on suitably simple lines.

9. This is by no means an unimportant detail, yet it is not given nearly the attention it should have. It is to provide the generating chamber (where the water and carbide meet) in duplicate, to have two (or more) of these chambers working separately so that one can be recharged when the other is only partially exhausted. The best way to realise the advantage gained is to see what transpires with a generator having but one chamber. Let it

be supposed that having given an evening's light it requires to be recharged the next day. It cannot be supposed that the previous evening's light used up every particle of the carbide, so that there will remain some unused when the chamber is opened for recharging. What has then to be done is to pick out the unused or partially decomposed pieces of carbide as far as is possible and restore these to the tray or basket when the sludge is emptied out. This, however, is a wasteful process, for it is not possible to pick out every piece that is unused: some parts are too far gone yet not quite exhausted. Furthermore, the whole operation is accompanied by a considerable release of gas and the sludge also gives off gas for some time. The consequence is that should the wind be lying towards the house the smell must be complained of. It is in fact a complaint often heard of and usually spoken of as a fault that accompanies acetylene lighting generally. The official rule that sludge from generators shall be emptied into tubs or holes and covered with water is based on the fault now described, whereas it should be quite unnecessary.

When the generating chambers are in duplicate it is, or should be, arranged that they work one after the other, and not together. By this plan recharging need only be done when it is seen that one chamber is flooded and spent. Then this chamber is emptied and recharged ready to produce gas as soon as the other has become exhausted. When the latter happens, then it, in turn, can be attended to while the previously charged one is producing the needed supply. The advantages of this arrangement cannot be over estimated. It effects a distinct economy in carbide. The sludge is odourless and harmless in all ways, and may

be used as slaked lime ; whilst the recharging operation causes no disagreeable odour of gas whichever way the wind lies.

10. All parts must be accessible from the outside for examination or repair.

11. Provision must be made that when the generating chamber is opened for recharging, the gas must not come back from the holder and escape. It can be readily understood that, with a clear pipe from generating chamber to gas holder, the pressure of the holder bell must cause a back rush of gas into and out of the chamber when the latter is opened, unless provision be made to prevent it. The provision may be a stop-cock—which is objectionable, as it may be forgotten ; or a check-valve—which is automatic, but likely to stick or be held open from some cause ; or it can be a water-seal—which is distinctly best. This provision exists in the condensers mentioned in (7) on page 59.

12. No part of the apparatus must be of copper, and all iron parts should be galvanised, to prevent corrosion.

The Exhibition of Acetylene Gas Generators (1898) and its important bearing on the Acetylene Industry.

It is felt that this chapter, dealing with the principles of acetylene generation, will be more complete if some information is afforded relative to the exhibition instituted by the Society of Arts, and held at the Imperial Institute, London, in 1898, as its purpose was to benefit the acetylene industry, to afford makers of generators an opportunity of having their appliances tested thoroughly and by the best authorities, thus putting acetylene lighting on a sound commercial basis, so that it might no longer

be considered an experimental or doubtful source of light.

The Council of the Society of Arts very generously arranged, on public grounds, to appoint a committee for this purpose ; and the value of their subsequent report can be readily judged by the perusal of the committee's names, as follows :

Major-Gen. SIR OWEN TUDOR BURNE, G.C.I.E.
K.C.S.I., *Chairman.*

SIR FREDK. BRAMWELL, Bart., D.C.L. F.R.S.

Professor JAMES DEWAR, M.A. LL.D. F.R.S.

HARRY JONES, M. Inst C.E.

Professor VIVIAN B. LEWES.

BOVERTON REDWOOD.

Professor SIR W. C. ROBERTS-AUSTEN, K.C.B.
F.R.S.

Professor J. M. THOMSON, LL.D. F.R.S.

SIR HENRY TRUEMAN WOOD, M.A., *Secretary.*

The character of the test generally was severe, and little has been said as to how many generators failed, or whose they were. In the first place the generators had to be fitted up and submitted to a preliminary test, for safety, on the premises of the London County Council, on passing which they were awarded a certificate admitting the apparatus to the Imperial Institute building for the official test and for exhibition. The test here lasted one month, and every apparatus had a weighed quantity of carbide served out to it, and was the subject of a daily report embracing every detail, even to the condition of the lime sludge. To the writer's own knowledge no test could have been arranged and carried out in a

more scrupulously correct manner, and no means of falsifying results were available.

The following is a copy of the Committee's Report to the Council of the Society of Arts :—

“It being common knowledge that, amongst the large number of generators constructed and sold to the public, there were some which did not conform to the ordinary conditions of safety, it was felt that in undertaking an Exhibition of Generators for Acetylene, a preliminary test should be made of all the generators submitted for exhibition, and that the generators which did not satisfy the necessary conditions should be rejected.

“The London County Council generously placed at the disposal of the Committee, premises in the Harrow-road, where the preliminary tests of all the generators submitted were carried out; and the various forms of apparatus as they were passed having been forwarded to the Imperial Institute, the Exhibition there was opened on June 15th, 1898.

“Although beyond the scope of their instructions, your Committee felt that in the interests of the public, it was advisable to carefully test the various forms of generators working for the period of a month, as it was possible that defects which might not be apparent in the test extending over a few hours might be detected on working over a longer period.

“Professor Vivian B. Lewes and Mr. Boverton Redwood were appointed as a Sub-Committee to examine into the working of the acetylene generators exhibited at the Imperial Institute, and to report to the Committee as to the results obtained and as to the generators to which certificates should be granted. The method adopted for testing is shown in Appendix C.

"As the result of these tests, the Committee advised the granting of certificates for those forms of acetylene generators, a list of which is appended, the certificate however, merely setting forth that the generator had complied with the requirements of the various tests to which it had been submitted, and had worked safely and satisfactorily during a month's everyday use.

"The Exhibition at the Imperial Institute has clearly demonstrated that many types of acetylene gas apparatus can be so constructed as with ordinary precaution to be absolutely safe, and that lighting by acetylene need be no more fraught with danger than are any of the other forms of artificial lighting in general use.

"In granting certificates to the various makers of apparatus hereinbefore mentioned, we wish it, however, to be clearly understood that such certificate can only apply to the type of machine examined and tested by us, and must not be taken as applying to all and every class of machine which may be offered for sale by the same makers.

"We consider that the various makers of apparatus who, at so early a period in the development of acetylene lighting, submitted their machines to the rigid tests as to safety laid down by your Committee, and have obtained certificates, are entitled to the first consideration from the public.

"There may be other forms of generators not exhibited at the Imperial Institute, which are perfectly reliable, but we strongly recommend that no machine should be purchased from any maker or dealer unless a certificate can be shown from some competent authority to the effect that it complies in substance with the rules laid down, and that it has been submitted to and has

satisfactorily passed the tests indicated. In this respect fire insurance companies could render great assistance to the public in refusing to insure without such a certificate being forthcoming.

"All the machines to which certificates were granted worked satisfactorily—some better than others. It is only fair to state that in the few instances where shortcomings were indicated the defects were in many cases remediable, and that possibly, owing to the experience gained by the exhibitors during the testing period, they may have been remedied since. Apparatus, therefore, should not be condemned because during the trials the working in any particular case was not all that could be desired.

"A point of considerable interest is the volume of acetylene gas produced per lb. of carbide used in each generator. Amongst the automatic generators there were three which gave, over the whole of the testing period, an average of slightly more than 4·5 cubic feet per lb., the remainder varying from slightly under 4·5 to as low as 3·55. Amongst the non-automatic generators one gave an average of about 5 cubic feet, the others showing much less.

"The carbide of calcium used both at the Harrow-road and at the Imperial Institute was supplied in bulk by the Acetylene Illuminating Co., Ltd., from Foyers, and was found to be throughout of excellent quality. It was weighed out and supplied to the exhibitors by Mr. Duffield, the assistant appointed by the Committee.

"Although it does not follow that the generator which yields the largest amount of gas is necessarily the best, yet this factor is a most important one in the choice of

any apparatus. The generators which combine the largest yield of gas with strength of material and simplicity in charging the carbide, and in emptying the residue, are those which will recommend themselves to the public.

“Where the public is most likely to be misled is in the exaggerated claims made by makers as to the number of lights which a given machine will supply ; and herein may possibly lie an element of danger due to excessive heating caused by too rapid generation. Even if there be no danger, the overheating will considerably lessen the quantity and lower the quality of the acetylene gas evolved from the carbide, as well as tending to cause smoking of the burners.

“We recommend that every apparatus sold should be accompanied by a written guarantee that it will light a specified number of burners, consuming a given quantity of gas per hour, over a consecutive number of hours without increasing the temperature in any part of the carbide receptacle above 228° C., that is to say the fusing point of tin.

“In regard to precautions to be taken, we endorse the suggestions of the Public Control Department of the London County Council and of the Corporation of the City of London.

“As to licences for storing carbide of calcium, we consider that Local Authorities need have no hesitation in granting such licences for storage, provided it be shown to their satisfaction that the material is properly packed, and that it is intended to store it in some dry and well ventilated place.

“We consider that no carbide should be purchased without a guarantee that it is free from any impurities

in quantities sufficient to cause danger, and the name and address of the manufacturer should be given on each package. The carbide should also be guaranteed to give off an average of 5 cubic feet per lb. when used in a good generator.

"The Home Office regulations allow 5 lbs. of carbide to be kept without a licence in packages of 1 lb. each. We recommend that, however small the quantity, it should always be kept in closed tins or bottles, under lock and key, and in a dry place. When its properties are more fully known, these precautions may not be necessary, as it is no more dangerous than many other substances in daily use.

"It was not within the scope of the work of the Committee to report upon portable apparatus and lamps to be used within the house. Your Committee, however, feel it their duty to state that, safe as they consider acetylene gas to be, when generated in a properly constructed apparatus outside the building to be lighted, and in accordance with the rules and suggestions contained in this report, they are of opinion that the generation of gas within the house is not unattended with danger, except in skilled hands.

"As to cycle lamps, carriage lamps, etc., though requiring only small charges of carbide, we consider that great care is required in their manipulation.

"We consider that non-automatic generators with a holder capable of taking the gas generated from the largest charge of carbide the generator will hold, are free from objections attending all automatic generators examined by us, and we are of opinion that every generator should be fitted with an arrangement by which all air can be rinsed out of the generating chamber by

acetylene or some inert gas before action is allowed to commence between the water and carbide.

"We are also strongly of opinion that every generator should be fitted with a purifying chamber or chambers, in which the acetylene is purified from ammonia, sulphuretted and phosphoretted hydrogen, and other impurities.

"The thanks of the Committee are due to Mr. F. G. Worth, of the Acetylene Illuminating Company, for the help he has given them throughout the investigation.

"We have the honour to be,

"Your obedient servants,

OWEN TUDOR BURNE.

FREDERICK BRAMWELL.

JAMES DEWAR.

HARRY JONES.

VIVIAN B. LEWES.

BOVERTON REDWOOD.

W. C. ROBERTS-AUSTEN.

J. M. THOMSON.

HENRY TRUEMAN WOOD, *Secretary.*"

Appendix C (Referred to in the Report).

"In order to ensure that no apparatus should be admitted to the Exhibition and shown in operation unless it had been previously proved to fulfil the requisite conditions of safety, the Committee appointed by the Society of Arts drew up the following rules for the admission of apparatus, the tests being carried out at the premises of the London County Council, 211 Harrow Road, London, W.

"The Committee have, for convenience in classification, divided the generators into three groups :—

1. Those in which the gas is generated by water being allowed to drip, or flow in a small stream, on to the top of the carbide.
 2. Those in which water rises around the carbide.
 3. Those in which the carbide falls into water.
- "These are again subdivided into :—

AUTOMATIC.

By automatic generators are meant those which have a storage capacity for gas less than the total volume which the charge of carbide is capable of generating, and which depend upon some special contrivance for stopping contact between the water and carbide.

NON-AUTOMATIC.

Non-automatic generators are those in which a holder of sufficient capacity is provided to receive the whole of the gas made from the largest charge of carbide which the apparatus is capable of taking.

"The following are the conditions laid down by the Committee which the apparatus admitted to the Exhibition of Generators at the Imperial Institute were required to fulfil :—

AUTOMATIC.

Rules.

1. Under no condition likely to occur in working must it be possible for the pressure in any part of the apparatus to exceed that necessary to support a column of water 100 inches in height.

NON-AUTOMATIC.

Rules.

1. Under no condition likely to occur in working must it be possible for the pressure in any part of the apparatus to exceed that necessary to support a column of water 100 inches in height.

AUTOMATIC.

Rules.

2. When the apparatus is first charged, in no case must the air in the generating chamber and receiver exceed one-fifth of the capacity of the apparatus.

3. On shutting off the outlet cock of the generator, the generation of the gas should be so speedily arrested that no large escape of gas may need to take place. But in any case there must be an arrangement by which any surplus gas can be delivered outside the building.

4. The apparatus should be so arranged that the decomposition of the carbide should not give rise to excessive heating.

NON-AUTOMATIC.

Rules.

2. The air space in the generating chamber should be as small as possible, and the apparatus should be so arranged that the decomposition of the carbide should not give rise to excessive heating.

3. There must be some arrangement by which, if the delivery pipe from generator to holder becomes choked, the gas can escape by blowing a seal or by driving back feed water and escaping through the tank.

“The tests made by the Committee were intended to show which generators were so constructed as to be safely admitted to work at the Exhibition, and do not imply any special approval on their part in any other respect.

“The Committee appointed Mr. W. W. Duffield, F.C.S., to carry out the tests at the Harrow Road, under the supervision of members of the Committee, and the following rules were drawn up for his guidance :—

" 1. No generator is to be tested until a blue print or drawing of the plant in section has been lodged, and a declaration signed by the exhibitor that the generator erected at the Harrow Road is in proper working order.

" 2. Mechanical details to be noted by the tester before the apparatus is charged : (a) Dimensions of generator chambers ; (b) charge of carbide used ; (c) cubic capacity of the gas-holder or storage chambers ; (d) what arrangements there are for condensing vapours carried over by the acetylene.

" Note.—By generator chamber is meant chamber or vessel into which the carbide is placed before decomposition, and it is necessary to know the cubic capacity of this in order to know how much air is driven over with the gas on first charging and working.

" Details to be noted during working :—

(a) Pressure in generator and in holder or storage chambers.

(b) Temperature in generating chamber.

" Note.—Sticks of tin, lead, and zinc of equal diameter are to be distributed throughout the mass of carbide in the generator, and on withdrawing the spent charge these are to be examined for signs of fusion.

" The melting points are : Tin, 228° ; lead, 334° ; zinc, 423° C.

(c) Exact weight of charge of carbide used, and length of time taken for its decomposition in the generator, *i.e.* until gas comes off so slowly that in practice the user would re-charge.

- (d) On withdrawing spent charge from generator, the mass is to be thrown into a pail of fresh water, and it is to be noted if a further evolution of gas takes place, as shown by the formation of bubbles and smell.

“Note.—Some generators often decompose the carbide to a very imperfect extent, and this makes the residue an active danger.

- (e) If the generator does not communicate with a gas-holder in which the gas is stored until cool, or if there be no proper arrangement for condensing vapours from the gas as it leaves the generator, then a Liebig's condenser of from 2 feet 6 inches to 3 feet in length may be attached to the exit pipe of the generator and the liquid condensed per lb. of carbide decomposed noted.

“Each apparatus was prepared for testing by the intending exhibitor or by his authorised representative.”

List of Firms to whom Certificates were granted.

The ABINGDON ACETYLENE ILLUMINATING Co., LTD.
The ACETYLENE BEACON LIGHT Co., LTD.
The ACETYLENE GAS CORPORATION, LTD.
The ACETYLITE SYNDICATE.
The BRITISH PURE ACETYLENE GAS SYNDICATE, LTD.
APPLEBY & HARRIS.
BAILEY & CLAPHAM.
BRITISH ACETYLENE GAS GENERATOR Co., LTD.
EHRICH & GRAETZ.
EXLEY & Co.
SIR CHAS. S. FORBES, Bart.
IDEAL GAS Co., LTD.

INTERNATIONAL INDUSTRIAL SYNDICATE, LTD.

LIVER ACETYLENE GAS CO., LTD.

MANCHESTER ACETYLENE GAS AND CARBIDE CO., LTD.

MIDLAND ACETYLENE (PARENT) SYNDICATE, LTD.

PINTSCH'S PATENT LIGHTING CO., LTD.

READ HOLLIDAY & SONS, LTD.

SARDI'S PATENT GAS GENERATOR SYNDICATE, LTD.

STRODE & CO.

SUNLIGHT GAS CO., LTD. (Goodwin's System).

THORN & HODDLE.

THORNTON-SCARTH AUTOMATIC LIGHTING SYNDICATE, LTD.

CHAPTER IV.

GENERATORS.

TYPES AND EXAMPLES.

It is, perhaps, desirable to say at the beginning of this chapter that the examples about to be given are chosen merely to form a representative variety in which the working principles differ, admitting of some instructive description. It is not within the province of a book such as this to criticise too closely either in favour of an apparatus or otherwise, but only to describe manufactures for the instruction of those referring to its pages. If any particular generator does not appear in this chapter it may be due to its principle resembling some other, or to the necessary particulars not being available. The majority of those generally used in this country are included, but to include all that have been devised is quite impossible, the number being enormous.

Carbide to Water Generators.—It has been stated, quite correctly, that simplicity is a very advantageous feature in generator construction, and nothing could be more simple than the principle of the following apparatus. This is the Pictet, a hand-fed, non-automatic apparatus, and Figs. 11 and 12 show the two forms in which it is made.

In Fig. 11 the carbide is dropped into the funnel-shaped feeding tube, through which it falls on to a grid

situated at the bottom of the wide part of the generating chamber. As the carbide is decomposed the sludge passes through the grid and collects in the tapered bottom part, from whence it is removed by opening the cock shown. The shape of the feeding tube, it will be noticed, prevents the gas, as made, rising up it.

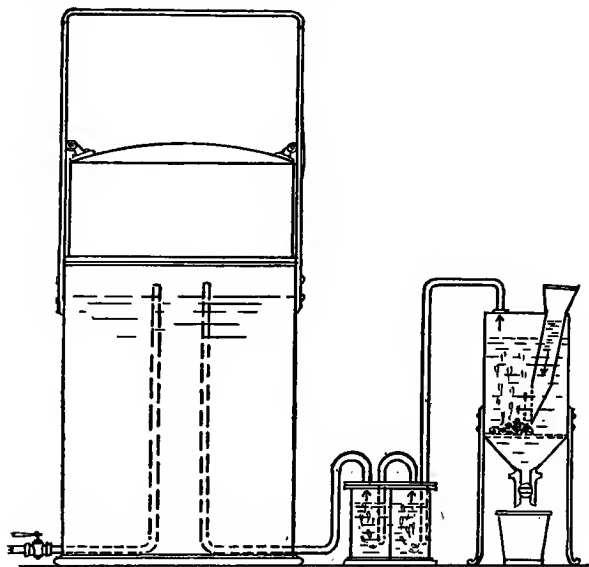


FIG. 11.

The object of the grid (on to which the new carbide settles, and remains until decomposed) is to prevent the carbide falling on to and becoming more or less embedded in the sludge of the previous charge. This would only occur in cases where the sludge was not removed, as it should be, prior to new carbide being fed in. It is peculiar to note that carbide to water generators, which

are considered to be so free from overheating, can, by the omission of the grid, develop heat as great if not exceeding that of the worst form of "drip" apparatus. If carbide falls on to and is more or less embedded in sludge, the evolution of gas is not free as it should be, and the cooling effect of the surrounding water is lost. The result is excessive heating, causing a crust, of what appears to be lime and tar, to form on the pieces of carbide if they are fairly large; and apart from these bad conditions it will be found that the carbide is not used up in the middles of the lumps. By providing a grid for the carbide to fall on, its contact with sludge is improbable except in cases of gross neglect of cleaning; yet even here there may be trouble if the generator is carelessly fed so that a heap of carbide is formed on the grid. This must not happen.

In Fig. 12 the sludge question is greatly simplified, as it is stated that the spent material comes away in the carbide holder when it is withdrawn. In charging, as the illustration shows, the can or holder has the specified amount of carbide put in; it is then lowered in the open part of the tank, and, on reaching the bottom, is pushed under the closed portion, so that the gas, which comes away very fast, does not rise up and escape into the air.

In practically all generators it is best to have the trays, cans, or other carbide holders, in duplicate to facilitate recharging. If there is but one it has to be taken out, emptied, rinsed out, then charged with carbide whilst wet. This causes an immediate production of gas, not involving much waste, but causing a disagreeable odour if the wind blows from the generating hut towards the house. By having a spare tray or holder it can always be quite dry when the carbide is put into it.

What are considered as disadvantages of hand-fed non-automatic generators are (1) the fact that a large gas holder is necessary. The gas holder must be large enough to hold a day's supply of gas at least; and should it be desired to have an apparatus that only requires

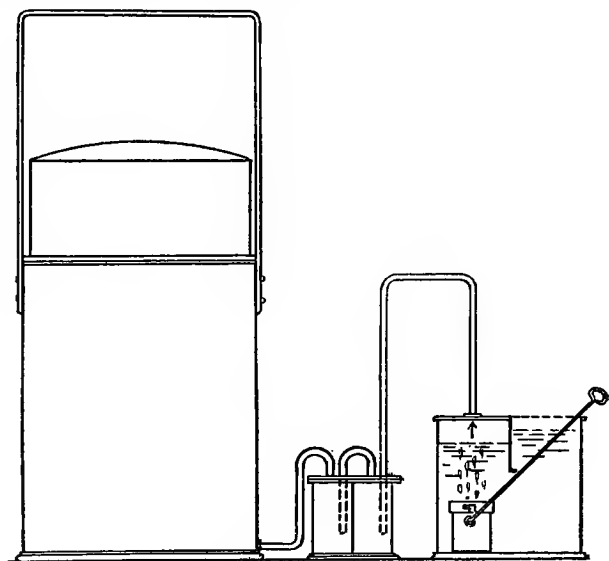


FIG. 12.

re-charging every other day or every third day (as is often required or preferred) then the gas holder must be twice or three times larger.* (2) The quantity of water used in generation is considerably in excess of that

* Automatic generators with gas holders usually have the latter capable of holding about one-fourth a day's supply. The carbide trays are divided up so that the whole of the carbide cannot be attacked at once, and the gas holder is made large enough to hold all the gas produced by one or perhaps two divisions of carbide.

absolutely necessary for decomposition, and as water absorbs acetylene somewhat freely, waste or loss of gas is attributed to this. This fault, if it may be called such, is not so bad in practice as it sounds on paper, for it is not necessary to have new water each time that new carbide is introduced, and this reduces the loss to each occasion that the water is renewed. It has to be renewed occasionally, as it becomes fouled with the impurities washed out of the gas—in fact the bulk of water makes the tank a generating chamber and condenser or washer combined.

The volume of water used would make it appear as if the small condensing tank, shown between the generating tank and the gas holder, was unnecessary. The purpose of condensing chambers is to allow the gas to bubble through water to rid it of condensable impurities and those susceptible to water treatment.

Another non-automatic carbide to water apparatus is the Rosco, Fig. 13. This much resembles the previous example, in that the carbide is simply dropped into water and the resulting gas goes to a gas holder, passing through a water vessel (condenser) on its way. Instead of an open carbide shoot, however, the new material is dropped through a kind of stop-valve having a very large opening through it. The carbide is received on a perforated tray, as shown.

A further non-automatic generator is illustrated in Fig. 14, made by the Sunlight Gas Company, Limited. This example is given under the heading of "carbide to water" generators, although really it should be classified as a contact apparatus owing to the water coming to the carbide from below (not the carbide falling into the water).

The apparatus is novel in that it provides for an admixture of 5 per cent. of carbonic acid to the acetylene during the process of manufacture. This combination is said to prevent the carbonisation of burners. The working of the apparatus is as follows: Into the chamber marked "Water" is put some plain water to which is

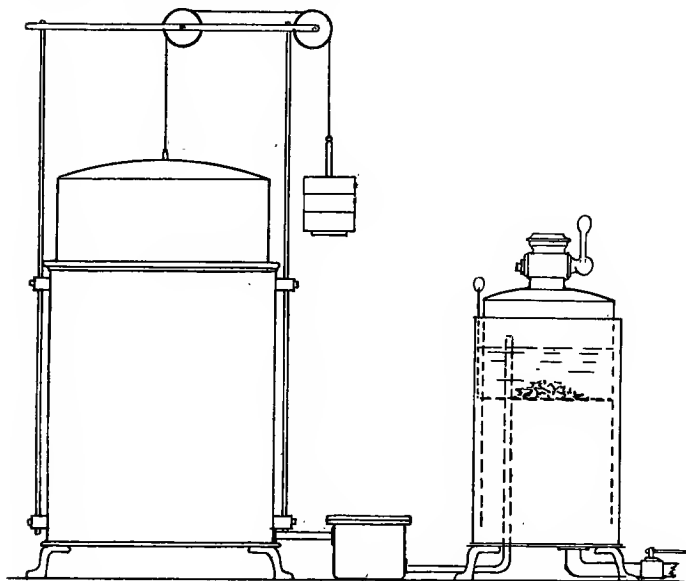


FIG. 13.

added 5 per cent. of sulphuric acid, the two being mixed together in the vessel. Into the generating chamber is first put half a pound of common chalk or whiting, and on top of this are added 8 lbs. of carbide. The cover of the generating chamber is then secured. A valve in the pipe leading from the water chamber to the generator

is then opened, and the contents of the latter slowly flooded. The acidulated water first attacks the chalk and produces carbonic acid, then it comes to the carbide and produces acetylene. The two gases next pass through the purifier which is charged with sulphate of copper in a moist state, and which rids the acetylene of impurities

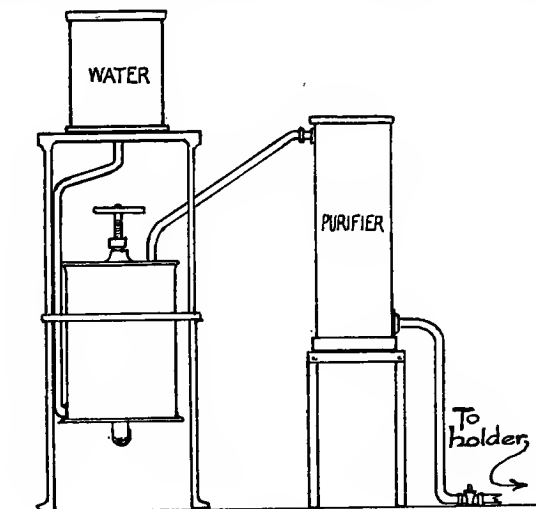


FIG. 14.

such as ammonia, sulphuretted and phosphuretted hydrogen. After passing the purifier the gases go to the holder as shown.

A non-automatic apparatus somewhat similar to the last one described, but minus the carbonic acid provision, is the "Ideal" illustrated at Fig. 15. This it will be seen consists of a strong cast-iron chamber with lid at top and residue cock at bottom. The carbide container is a perforated cylinder resting on projections

as shown. At the side of the chamber, externally, is a water supply pipe with three inlet cocks. The bottom one is ordinarily used, the upper ones being for emergency only, supposing the lower one should get stopped up. A water gauge indicates the rise of the water in the chamber when it is turned on.

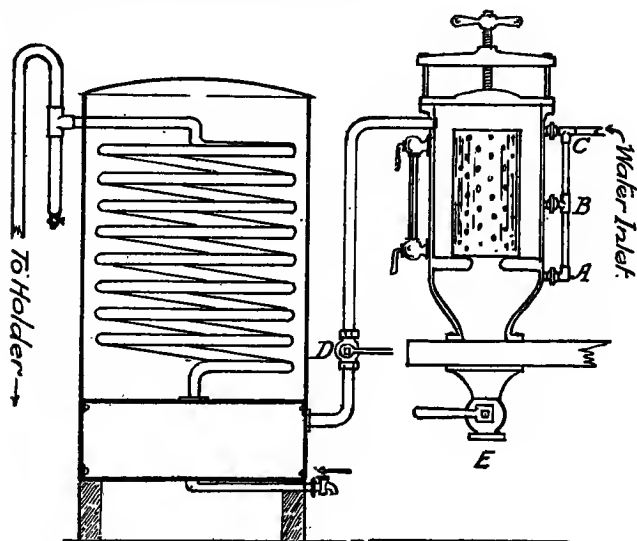


FIG. 15.

The tank at the side with coil in it, is termed the "cooler," its purpose being the same as a condenser, only that the gas does not have contact with water. The gas as it comes over from the generator first enters a chamber at the base of the cooler, this chamber receiving the condensed products. The operation of charging the plant when it is in regular use is as follows. First close the tap D. Draw off the residue from the tap E. Remove

cover of generating chamber and lift out the carbide holder. Clean the inside of generating chamber and water gauge by washing it all out with water. Next

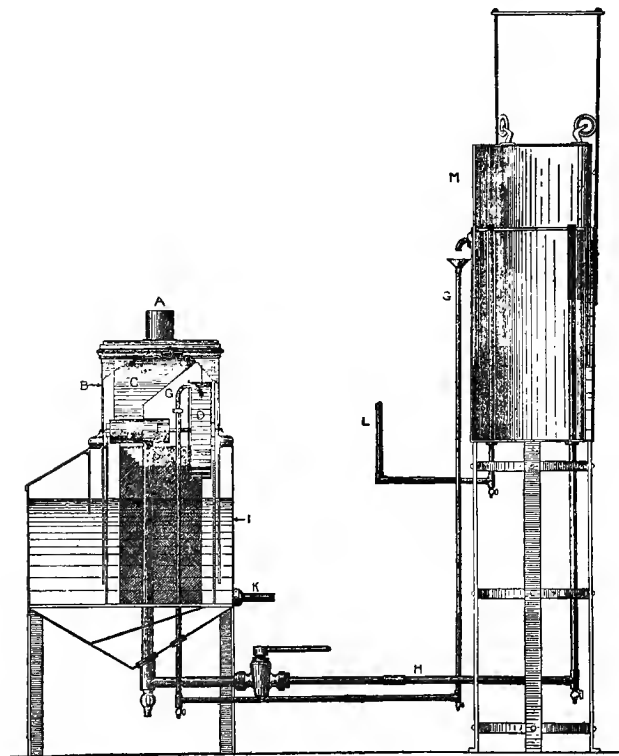


FIG. 16.

open tap A and run in water up to the ledges on which the carbide container rests. Place container of new carbide in, replace and secure the cover. Open the tap D Turn on water again at A and watch the water rise

up the water gauge. When it reaches the top of the gauge close the tap A and the operation is finished.

Another example of carbide to water generators is Strode's patent illustrated at Figs. 16 and 17.* This differs from the previous ones in being automatic in action, a mechanical device delivering fixed quantities of

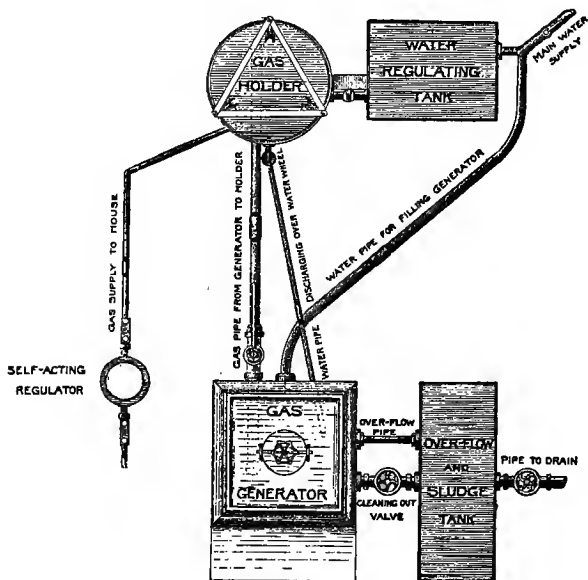


FIG. 17.

carbide into the water as the gas is used. The gas holder, therefore, does not require to be so large as with the non-automatics previously described.

With the many inventors of automatic acting generators only a small minority have succeeded with the

* Reproduced from the manufacturer's illustrations.

carbide to water principle. It is considered more difficult to attain, and there are fewer ways of getting the desired end satisfactorily. In this example, the carbide is first placed in the receptacle C, and here it remains until the revolving spindle E turns and causes some of the carbide to fall or be delivered into the water below. Immediately this occurs gas is evolved and passes by way of the pipe H to the gas holder. The outlet from the holder is the service pipe L.

The automatic detail is chiefly in the small water wheel D. When starting the generator the apparatus is first filled with water by the pipe and cock provided, then carbide is put in the chamber C. A little water is then poured into the funnel of the pipe G until sufficient gas is made to raise the holder several inches. After this the water feed is quite automatic. The fall of the bell of the gas holder causes the water line in the holder tank to rise and overflow into the funnel, as the bell is slightly larger at top than at bottom. The water-regulating tank, which has a system of double ball-valves, replenishes the water in the holder tank as required.

To re-charge this apparatus, the gas valve in pipe H is first closed, then the top of generator is opened and chamber C re-charged with carbide, after which the top is closed and the gas valve re-opened.

To clean out the apparatus while working, the fullway cleaning-out valve at the side of generator is opened to allow the sludge to run into the overflow tank. To effectually do this, the lid in front of generator is opened and the sludge stirred. When the sludge has passed out the generator tank is refilled with water. The sludge is subsequently run into a drain or emptied into pails.

The lettering in the illustrations is described as follows :

A, removable cap for replenishing carbide chamber C.

B, removable cover. This can be lifted quite up and off, and immediately exposes all working parts.

C, carbide chamber.

D, water-wheel, which operates the feeding spindle E.

E, a revolving spindle, which carries a screw blade, and as the spindle works round, the screw delivers carbide from C to the water below.

F, perforated strainer.

G G, the water pipe which operates the water wheel.

H, gas pipe from generator to holder.

I, the water tank of the generator.

K, filling pipe to generator tank (see second illustration).

L, gas service pipe to house.

M, gas holder.

Another method or "system" of automatic carbide-to-water generation has for its working part a kind of spindle valve. Fig. 18 illustrates the principle of this, but certain details must be provided to prevent the carbide falling on to the sludge, also to clean out the sludge, etc.

The apparatus consists of a tank, with bell much like a gas holder, and the bell carries the carbide chamber C. The latter is charged with carbide in a rather finely granulated form to admit of its passing the valve when it lifts. The valve fits the opening at the bottom of the carbide chamber, and to this is attached a rod, weighted at the end, and extending down to the bottom of the tank when the bell is near its lowest position. When the lower end of the rod touches the bottom and the

bell falls a little lower, the valve is caused to rise from the opening at the bottom of the carbide chamber and a proportion of carbide falls through. This, of course, immediately produces gas, causing the bell to rise and the valve to close the opening again.

In Leroy and Janson's generator, Fig. 19, the same principle is observed, but to avoid the varying weight

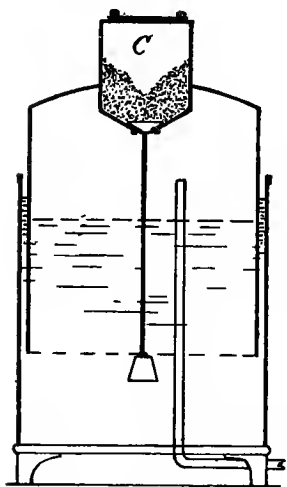


FIG. 18.

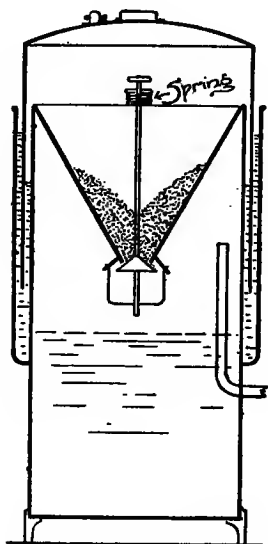


FIG. 19.

and pressure caused by the carbide chamber being on the bell, the chamber is fixed internally and the bell left free. It is not usually considered the best plan to have the bell of a generator such as this, or a gas holder, loaded with anything causing an unnecessary or a varying pressure. Variation in pressure would, in

Fig. 18, be caused by the varying quantity of carbide in the chamber C.

It will be seen in Fig. 19 that the carbide hopper is attached to the upper rim of the tank, while the bell works outside it. To keep the bell gas-tight the outer water space shown is provided. As the carbide chamber is motionless the valve at its bottom opening is operated by the bell pressing on the valve rod which rises up through the carbide hopper, as will be seen. The spring marked pulls the valve up to the opening, closing it when the bell is not pressing the rod down.

In this also there has to be provision made to prevent the carbide falling on to sludge, also for removing sludge as required. The carbide has to be in finely granulated form.

Still another example of what has been termed the "valve system" of carbide-to-water generation, is the Acetylite patent. Fig. 20

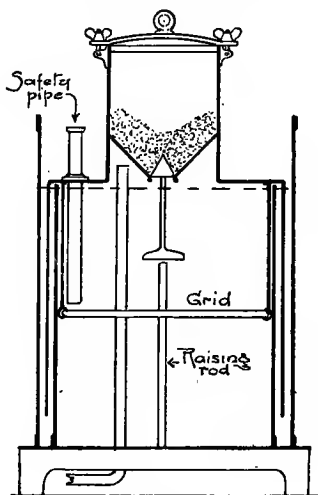


FIG. 20.

illustrates this, and it will be seen to resemble the last two examples in principle, though not exactly in detail. The carbide hopper is fixed on the bell and is charged by removing the lid which is at the extreme top and is secured by thumb screws. The valve is inside the carbide hopper like Fig. 18, but coned the opposite way. This valve has a drop rod weighted at the end.

Instead of the drop rod extending down to the bottom of the tank there is a "raising rod" provided as shown, and it can be set to the best height by a connection at the bottom. A safety pipe is provided where shown, this being attached to the bell and rising with it. If by a heavy blow or other mishap the fall of carbide from C should be more than necessary, the bell on rising

to its greatest height lifts the lower end of the safety pipe above the water and this provides a clear outlet for the excess of gas. This pipe should be carried up overhead and outside the generator house into the air; but, as the pipe is not stationary, it would require a flexible connection to admit of this.

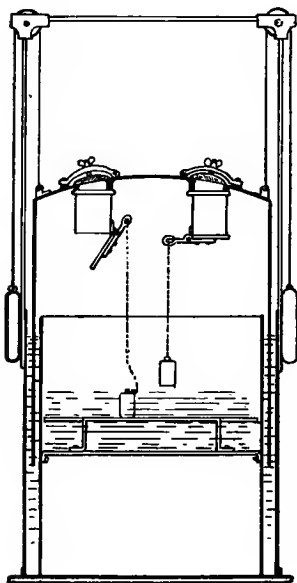


FIG. 21.

A good feature is the perforated grid marked. This receives the carbide as it falls from the hopper, instead of allowing it to drop on the sludge below. The raising rod, the gas-service pipe and the safety pipe are all arranged to pass freely through the grid as it moves up and down. Sludge and emptying cocks are provided.

A further method of discharging carbide into water is embodied in the "latch" type of generator. Fig. 21

illustrates one principle followed, but it may be mentioned that there are several others. In this example it will be seen that the bell of the combined generator and gas holder carries several small carbide chambers.* These have external lids at top secured by compression screws as usual. The bottom of each chamber is hinged and weighted in such a manner that it falls open readily; but for the purpose of keeping it closed until the right moment for discharging the contents, each bottom has a lever attachment, and to this is suspended a weight. It will be seen that when the bell descends far enough for the suspended weight to rest on the bottom of the chamber, and no longer exert a pull on the lever bottom of the carbide holder, the latter must fall open and discharge the carbide. By simply arranging to have the weights suspended at different heights it is possible to discharge the chambers successively, one at a time, until all are empty.

Generators which operate as a gas holder and carry carbide chambers in the rising bell require the latter to be counterbalanced to allow of its rising freely as the gas is made, without undue pressure being exerted and without, in turn, causing the bell to exert undue pressure in the gas-service pipes. The balance weights shown regulate this, but they do not provide for the varying weight of the bell, the difference there is when the carbide chambers are full and when empty. As previously stated, it is best not to load the bell at all in this way.

A grid is provided for the carbide to fall on, and as the fall of the bell is very gradual the opening of the carbide holders is gradual also; therefore the carbide is

* Only two are shown in the illustration, but a series of four or more is usual.

not shot down in a heap at once. The suspended weights rest on the grid, not on the bottom of the generating chamber, when the bell descends low enough.

Other forms of carbide to water generators of the "latch" type include two distinct kinds. In both we may suppose the generating tank, and shoot for the carbide, to be somewhat similar to the Pictet, Fig. 11, page 77. Instead of the carbide shoot being clear at top there is a horizontal wheel, around the circumference of which is a series of carbide cells or holders. The wheel is caused to revolve by mechanism connected with the bell of the generating chamber or gas holder. As each carbide cell comes over the shoot a simple latch mechanism causes the bottom to fall open, precipitating the carbide down the shoot into the generating chamber. The immediate evolution of gas causes the gas bell to rise, and not until the gas is used and the bell falls again does the wheel revolve further and furnish more carbide. It is a successful and somewhat simple plan, though introducing more mechanism than is generally thought desirable in acetylene generators.

The remaining "latch" type of generator to be referred to is similar to the last in the fact that a wheel revolves and brings successive charges of carbide over the carbide shoot, automatically as the gas is used. The wheel, however, revolves on a fixed circular plate having a hole over the carbide shoot, and the carbide cells have no bottoms. It will therefore be seen that as each cell comes over the open hole its contents must fall down the shoot into the generating chamber. It would scarcely do to use fine carbide for fear of its wedging in between the wheel cells and the fixed plate, but with ordinary lump carbide there should be no trouble.

The Dipping Principle of Carbide-to-Water Acetylene Generation.—This is clearly a carbide-to-water process, but differing from the other (greatly in results) in the fact than when the carbide is plunged into the water it is almost immediately lifted out again—it is just dipped.

Fig. 22 illustrates an elementary form of generator, such as a mechanic might make at home for lantern work or any similar small purpose. It consists of a miniature gas holder made of zinc, the bell having an aperture at top large enough to admit of the carbide holder being dropped through or withdrawn. The hole is closed with a loose cover having a rubber collar round its rim, and this, by the weight of the carbide holder, makes a gas-tight joint when the whole is ready for use.

The carbide holder must be of galvanised iron, for the heat developed by this dipping method has been known to be sufficient to melt zinc. This is of course a drawback to the dipping method of generation, or to any method in which the water is caused to come away from the carbide before decomposition is completed.

Dr. Caro's investigations have shown that the "dipping" system under some conditions can give as bad

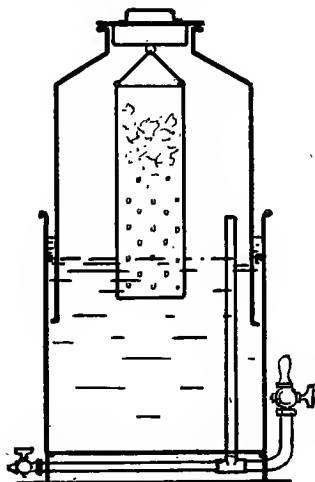


FIG. 22.

results as the "drip" principle, although at first thought it might be considered differently. The fault is in the fact that water in bulk only remains in contact for a brief time, for immediately the carbide holder touches the water there is production of gas and a rising of the bell which lifts the holder clear in a very short time. It does not touch water again until the gas is used, and then it is only another momentary dip.

The result is that except for a few seconds the carbide is in excess of the water in contact with it, and this is favourable to overheating. Lewes has made experiments under careful conditions, but chiefly to determine what temperatures could be obtained in bad cases. On several occasions the whole of the carbide charge became a glowing red heat, giving off steam and tar fumes, and sometimes the distinguishing odour of acetylene was scarcely perceivable in the strong tarry smell evolved. He points out that with excessive temperatures such as these changes of great complexity occur, bringing into existence many troublesome or useless gases besides products of polymerisation, particularly tar which brings about stoppage in pipes, etc. Last, but not least, it was found that the illuminating value of the gas was greatly reduced, even as much as from 240 candles to about 126. In nearly every experiment the heat rose to that at which polymerisation of acetylene commences.

An example much resembling the last one is that designed by d'Arsonval. This is illustrated at Fig. 23. In this case the cover is made tight by a water-seal, and provision is made at bottom for running out the sludge, which is precipitated there, without emptying all the water out.

A special feature of this generator is that the water is

covered with a layer of oil. When the bell rises and lifts the carbide basket out of the water the oil clings to and coats it so that after-generation more quickly ceases. This oil is supposed to float off when the carbide once

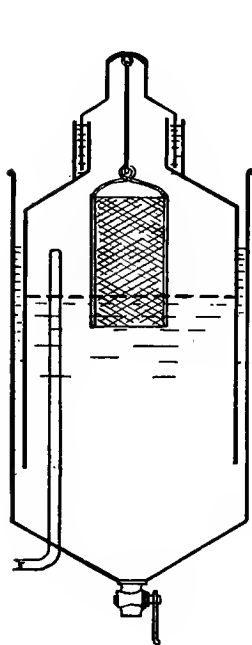


FIG. 23.

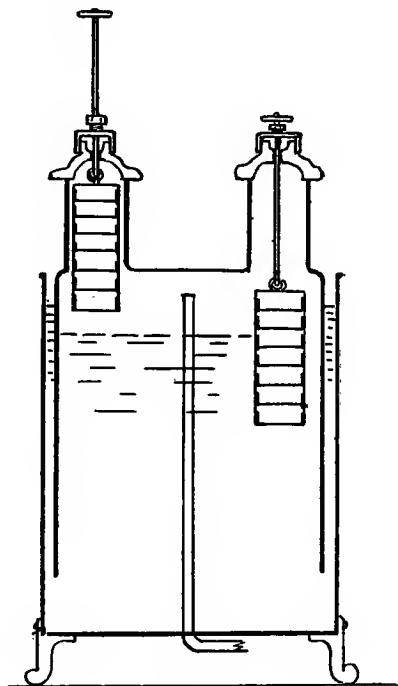


FIG. 24.

more dips into the water and then cover the carbide again when the bell rises.

In the "Gabe" generator, Fig. 24, the best known method of reducing the overheating of the dipping system is practised. This is to limit the quantity to be flooded for

the short time it is immersed. With this generator the carbide is in two (or more) holders suspended from the lid of the bell. Each basket is suspended from a rod which passes through a stuffing box above. By this arrangement only one carbide holder is acted on at once, this one having its rod pushed down so that it is low enough to touch the water when the bell is down. When this holder full of carbide is exhausted, another one is pushed down, and so on until the apparatus wants re-charging.

The holders for the carbide are perforated cans or cylinders, and these carry several small trays partially filled with carbide. Thus, on dipping, just a tray of carbide is acted on without seriously affecting the bulk above, and only as the lower trays are exhausted are the upper ones affected. This apparatus has a fault, possessed by some others, in that, when the carbide holders are re-charged, whatever gas there may be in the bell is wasted and this is replaced by air. On closing up the apparatus and making gas there is, at first, an explosive mixture of gas and air delivered at the burners which might light back along the service pipe to the generator if the burners permitted it. Fortunately the orifices in ordinary acetylene burners are so small that the flame cannot pass back through them however explosive the contents of the service pipe might be, but if a workman applied a light to a bracket (before the burner was put on, just to see the gas was coming, for instance), there is a probability that something disastrous might happen.

All authorities now agree that generating chambers which have a fair bulk of air enclosed each time they are re-charged should have a provision for expelling or

rinsing out this air to prevent the service pipes being charged with an explosive mixture. In instances where the generating chambers are separate and cut off from the gas holder (by cock or water-seal) when they are re-charged, and are of comparatively small size, the air is not in sufficient volume to be dangerous.

Another generator on the dipping principle which may be noticed is the Sardi apparatus, Fig. 25. When first constructed the carbide was contained in one long cylinder, like Fig. 22, but this caused such serious overheating in the generators of moderate and large size that the arrangement illustrated was finally adopted and very greatly reduced the trouble. In this the dipping cylinder is subdivided into a number of cells, so that the water only acts on a small independent quantity of carbide at a time.

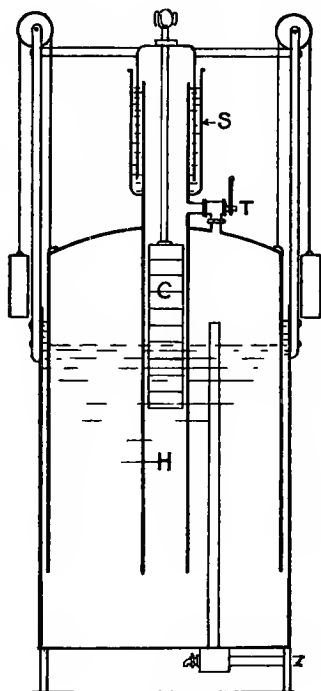


FIG. 25.

The dipping cylinder with its trays or cells of carbide is marked C, and this is suspended by a rod above. To enable the carbide cylinder to be withdrawn the second miniature holder or water-seal marked S is necessary. It will be seen that by lifting the knob at the top, the

cylinder can be withdrawn without any mechanical aid ; and, provided the tap T is closed, the gas already contained in the holder will not escape. This is ensured by the long cylinder H, which encloses the carbide cylinder. No provision is made for washing the gas in the generating apparatus, so it should be passed through water before going to the purifier or house. The bell of the holder is counterbalanced as is requisite when the bell carries the carbide.

The Drip Principle of Generation.—This principle of generation, as originally devised, is distinctly bad, and has done much to injure the acetylene industry, yet there is a drip machine now being made and sold (the Forbes) which has a good reputation and brings profit to its makers. It is just a question of what the water drips on to.

In the original machines the water was allowed to drip on to the mass of carbide, the dripping being started or stopped by the opening or shutting of a cock worked by the movement of the gas-holder bell. The fault lay in the fact that the water ran on to the top of the carbide, a way of applying water which must cause trouble, and which, to the best of the writer's belief, does not occur in any existing generator. The fault would have been lessened, though not obviated, if the water had been in large volume, but whether in large or small quantity the water must not drip or be poured on top of the carbide.

If a charge of carbide is put into a tin holder, or is merely heaped up on a plate, and water is allowed to drip on top it will be found, firstly, that the heat generated is excessive, due to the water being in insufficient quantity (as already explained) ; secondly, that the

sludge of the top decomposed carbide will spread over and cover the remaining carbide and prevent further free generation. There will be sufficient moisture to make a heat far in excess of what is experienced with any other principle of generation. There will be polymerisation and the existence of troublesome products in their worst forms; and the general results, as regards lighting, will be wasteful and bad. The difference between letting water fall slowly on to the top of carbide and letting it come up from beneath, is very great, both in general results and in economical working.

A good type of drip machine is that of Sir Charles Forbes and known as the Forbes generator. Fig. 26 illustrates this. The apparatus consists of a horizontal cast-iron cylinder closed at one end, and having a cover E on the front, which is clamped up against an india-rubber packing ring F.

On the top of this cylinder is a water vessel G containing an inverted gas bell H, supported on a wide pipe I, which passes up inside the inverted gas bell nearly to the top. The bell is supported in position in the tank by means of a cone J formed on the upright pipe, which also acts as a valve for cutting off the water when re-charging, or if it is desired to put any generator out of action; the automatic action of the generator, however, does not in any way depend on this valve. The water has access under the lower edge of the inverted gas bell. A small tube K is fixed in the side of the upright pipe within the bell to admit water to the carbide.

The working of the apparatus is as follows:—When the generator is charged with carbide, and water admitted to the tank from a controlling cistern (usually fixed on the wall, and made to supply all the generators in the

plant), the water rises under the bell of each generator until it reaches the small tube, and then falls into the carbide drawer L in the cylinder below. The gas is im-

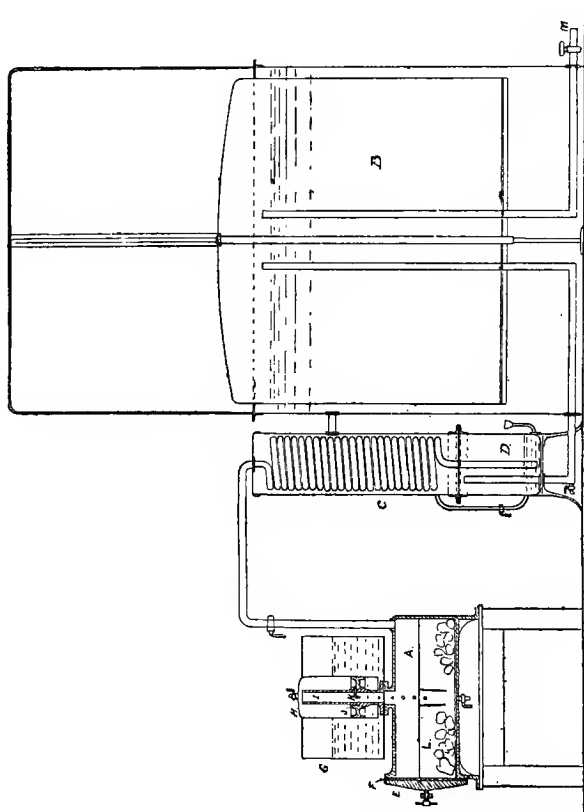


FIG. 26.

mediately generated, and passes into the holder, which rises until its weight balances the head of water in the generating tank or tanks. At this point the water is

automatically displaced below the level of the small inlet tube, when it ceases to drop into the carbide tray. The generation then shortly ceases, and is not resumed until further call for gas is made upon the holder.

When the holder falls again to the balancing point, the generation of gas recommences and so on until the charge is exhausted.

When the gas leaves the generator it passes in at the top of the condenser C and is delivered downwards into the washer D, thence to the holder, and finally to the gas meter or main M.

Generators of the Contact type.*—This method of generation is distinctly favoured at present as the gas is made under normal and good conditions, and the principle readily lends itself to automatic generation of a perfect kind. Although non-automatic generation is practical and good, it will never quite meet all general requirements, and as automatic generators on the contact principle are now made to give excellent results, they are likely to have much the greater demand.

A generator that meets about all the requirements of a perfect apparatus of this kind is that illustrated at Fig. 27. It consists of a gas holder, in the centre, and two sets of generating parts, duplicates of each other, one on each side of the holder.

In the first place it may be mentioned that an apparatus is at a great advantage in having the generating parts in duplicate, working separately and alternately so that when one is exhausted and the second has commenced to work the exhausted one can be opened and

* Two generators which may be considered as working on the contact principle, are included with the non-automatic examples described at the beginning of this chapter. They are the "Sunlight" and the "Ideal."

re-charged. This should be possible without interfering with the one in operation and without losing gas. By

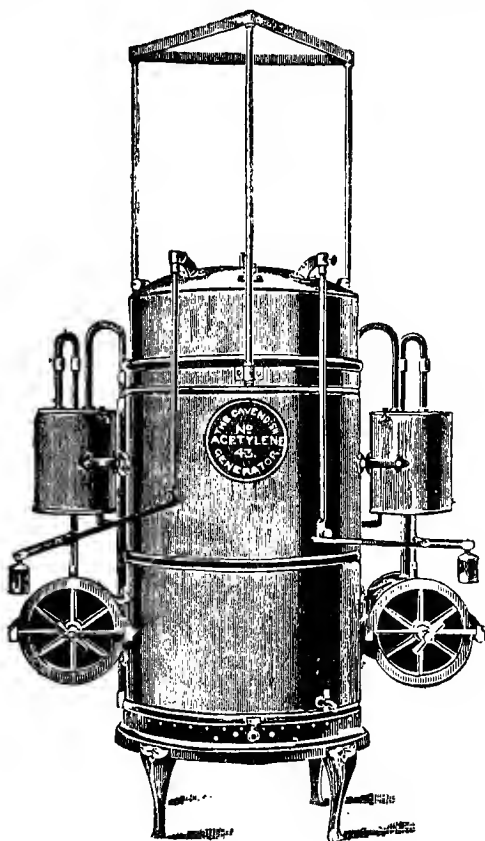


FIG. 27.

this plan daylight re-charging is always possible without waste, an impossible state of things where a single generating chamber only exists.

With the latter let it be supposed that the charge of carbide is nearly exhausted. What has to be done? Shall it go on and probably cause the light to fail during the evening; or, shall the generator be opened, and what part of the charge remains unused be thrown away, or, if possible, be picked out and replaced? There is no middle course with a single generating chamber, for either the attendant must wait until the present charge is exhausted (which would be while the gas is being used), or opportunity must be taken during daylight when it is considered that the remaining part of the charge unused is small and will not last the coming evening through.

In the example now being described, the water supply to the generating chambers is operated by two drop rods suspended from the bell of the holder in front, these rods pressing on the balanced levers which work the water cocks. One rod is longer than the other, and the length is arranged that one generating chamber receives its water and is eventually flooded before the second one comes into operation. In other words, one chamber receives water when the bell is about half-way down, while the other gets no water until the bell comes lower. In operation the generator in communication with the longest rod is exhausted first, and it can then be opened and re-charged while the other is working. The only extra detail is to change the rods (they are held in by thumbscrews) each time of charging so that the newly charged chamber is given the shortest rod each time. In the illustration the right-hand generating chamber is receiving water as the long rod has pressed the lever down far enough to turn the cock about half on. The left-hand chamber has not received water yet, and may be considered as being newly charged.

On each side of the holder is a condenser or washer as well as a generating chamber, and Fig. 28 will serve to describe how generation occurs. In each generating chamber is placed a tray half filled with carbide, and the tray is fitted with a lid. No lid is shown in the illustration as it is desired to show how the tray is divided into

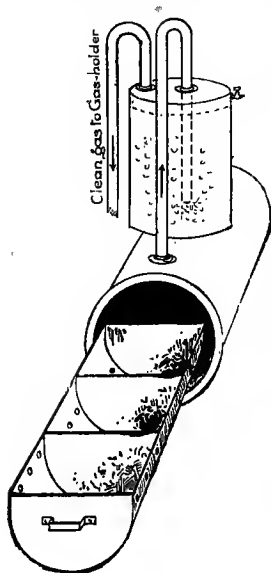


FIG. 28.

water-tight compartments with holes at the sides at different levels. The purpose of this arrangement will be explained directly.

When the gas comes off from the carbide it passes up a pipe from the top of the chamber, this pipe rising a little above, then dipping into the small cylindrical condensing or water chamber. The pipe dips down about three-fourths the way to the bottom so that the gas is discharged below water and has to bubble up through it before it can get away at the top. This the illustration shows. The condensing chamber does not quite fill with water, the small space at top giving opportunity for the gas to get away freely into the pipe which conveys it to the holder.

The carbide tray is divided into compartments that the carbide may be used in small quantities at a time, and this is effected by the rows of holes shown at different levels. As the water enters the generating chamber it rises up from the bottom and first enters the compart-

ment with the lowest holes. As the water rises it next enters the compartment with the holes half-way up, and so on. By this plan the carbide in one compartment is exhausted, or very nearly so, before the next is attacked. The water that enters stays in the compartment and floods that portion of carbide which it touches. The re-charging, it will be noticed, only requires the front lid to be removed, the tray of spent material to be drawn out, a tray of fresh carbide to be slipped in and the lid replaced.

The water supply is by a small cistern attached to the holder, at the back, and not shown in the illustration. This has a ball-valve in it, and the water level is arranged to come about an inch below the tops of the condensers as the water from the cistern runs into these. Fig. 29 illustrates the water supply, and it

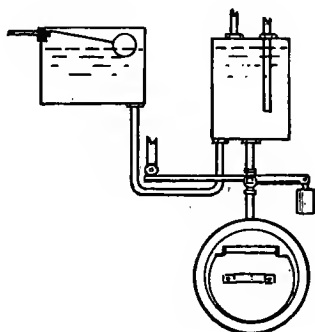


FIG. 29.

will be seen that all the water used in the generating chamber comes through the condenser. This plan admits of a simple automatic change of water in the condensing chambers, preventing it becoming seriously fouled by the impurities washed out of the gas, and giving back whatever acetylene the washing water has absorbed. The fact of the water being used to wash some gas previous to its entering the generating chamber is no fault or disadvantage. The water of the gas holder is not used. It will therefore be seen that the whole of the working or mechanical parts of the complete

apparatus are two water-cocks and a ball-valve. There is nothing of a complicated nature.

The Dargue generator, illustrated by Figs. 30 and

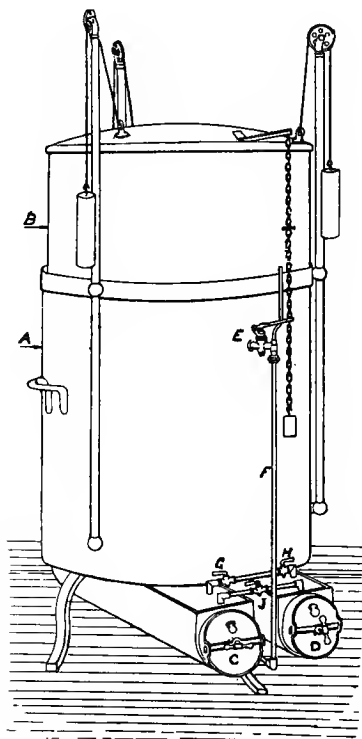


FIG. 30.

31, somewhat resembles the last in having generating chambers containing carbide trays divided up into water-tight divisions. In this, however, the water entering one

division overflows into the next and by this means deals with each portion of carbide separately.

In this apparatus the water of the gas holder serves two extra purposes. One is that it furnishes the water needed for generation, the other is it does the washing which the gas needs to rid it of condensable products.

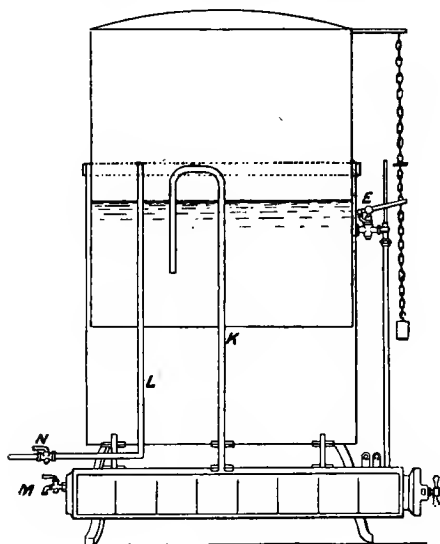


FIG. 31.

The parts of the apparatus are as follows : A is the tank of the gas holder ; B is the bell of the holder ; C and D are the generating chambers ; E is the water-supply valve, operated by the rising and falling of the holder bell as shown ; F is the water-supply pipe, from cock down to the piece of pipe between G and H ; G and H are the taps controlling the water supply to the two

respective generating chambers; J is a bye-pass pipe between the two generating chambers with one tap in it as shown. K is the gas pipe from generating chamber, rising to above water level then dipping down some inches below so as to cause the issuing gas to bubble up through the water and thus be washed; L is the gas-supply pipe to purifier or to house; M is a try-cock to ascertain if the generating chamber is exhausted. If on opening this cock gas issues then the charge is not exhausted. If water comes, then the charge is flooded and finished; N is the stop-cock usually put in the main gas pipe.

The operation of the apparatus is as follows:

Let the tap G and the tap of the bye-pass J be open. Then as the gas is used the bell of the holder will descend and turn on the valve E. The tap G being open, water will flow into the generating chamber C and make gas. The bell of the holder then rises and shuts off the water. As the gas is used the bell descends and turns on the water-valve E again, and so on until the chamber C is flooded and exhausted. When this happens the water will next overflow through the bye-pass J and commence to act on the contents of the other generating chamber D and eventually exhaust this.

Before D is exhausted, however, the chamber C can be re-charged. To do this, close the cocks G and J, when the lid of C may be removed and the contents renewed while D is making gas. On closing the chamber and re-opening the cocks G and J the operation explained in the last paragraph takes place again, but in the reverse direction.

Still another example in which the carbide is carried in trays in horizontal cylindrical chambers is Thorn and

Hodde's "Incanto," illustrated by Figs. 32 and 33. This differs from the apparatus illustrated at Fig. 27 in the fact that with the latter all parts are external to the holder, while in the example now illustrated the working and other parts are mostly inside.

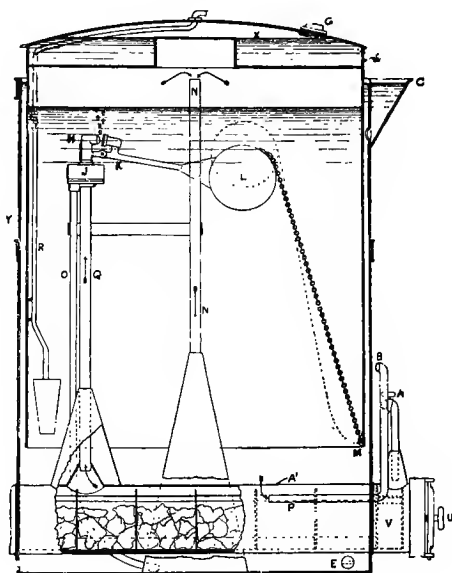


FIG. 32.

A description of the apparatus, as published by the makers, is as follows :

The cocks A or B are opened and water flows through the pipe P into the generating chamber. Acetylene is evolved and passes up the pipe Q, past the non-return valve and out at the open valve K into the gas holder W, which steadily rises as gas accumulates until the chains

become slack and the ball-valves close. The gas in the generating chambers, having no other outlet, now forces back the water in the pipe P and bubbles up through the water into the gas holder until generation ceases.

The pressure in generating chambers then being equal to the head of water in tank, no more water can

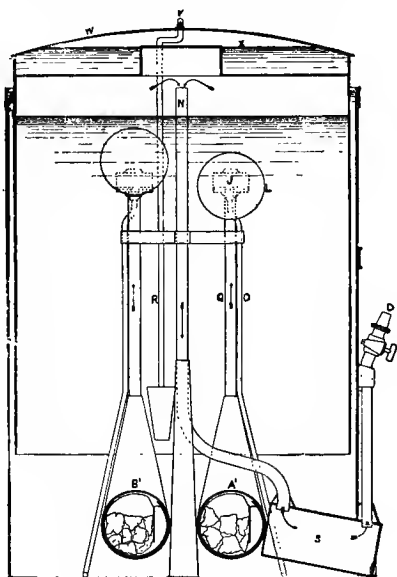


FIG. 33.

enter until gas is drawn off at D ; the gas holder then sinks until it opens the ball-valve K on A₁ generating chamber ; the valve on B₁ remains closed owing to its longer chain, and B₁ will not come into use at the same time as A₁. Directly the ball-valve opens, water enters again at the pipe P and the action is repeated as before.

When the carbide in A_1 is exhausted, the container fills with water, the gas holder falls low enough to open the ball-valve of B_1 , and that chamber comes into use ; then, while it is in action, the container A_1 can be re-charged if desired.

The chamber S is the condenser ; a small screw-plug is provided for draining.

Instructions for Charging.—Unscrew and remove cross-bars and plates U from the generating chambers A_1 and B_1 ; take out the carbide containers V, and about three parts fill the compartments with carbide, thus allowing for expansion of residue. Replace the containers with opening upward, and drop-handles to the front ; also replace plates and cross-bars, and screw up thumb-tight (no tools are necessary), being careful that the rubber washer is property in position, and that no residual lime prevents a gas-tight joint.

When the gas is required, turn the tap A about half-way on, and gas will immediately begin to generate. When the holder has risen about 6 inches, push up the indicator, and turn taps A, B and D full on and leave them so. Open cock D and some burner cocks, and a light will be obtained when all the air has been expelled from the service pipes, but it will not be perfect for at least an hour.

If the lights are burning, gas will continue to generate in the generating chamber A_1 until same is exhausted, when it will automatically start generating in B_1 .

The Indicator.—The lines A and B marked on the tank Y, correspond with the generating chambers A_1 and B_1 ; and when the indicator is pushed down by the gas holder to the line B, it indicates that A_1 is exhausted and B_1 is working.

The generating chamber A_1 can then be re-charged if desired, in which case gas will commence to generate again in A_1 if the tap A is turned on. The indicator should then be pushed up, and B_1 will again come into action after A_1 is again exhausted, or B_1 can be worked out by keeping the A tap turned off until required.

A contact apparatus in which the generating chambers

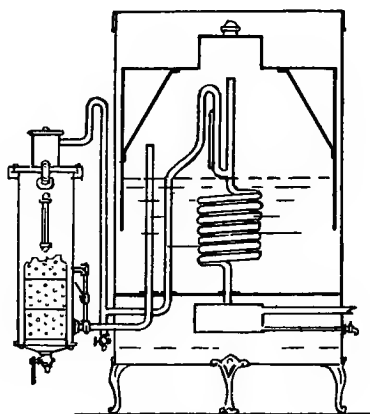


FIG. 34.

and carbide holders are vertical, is illustrated by Fig. 34. This is the Thorscar generator, and its operation is as follows : *

The apparatus consists of a gas holder and a vertical generating chamber. In the latter the carbide carrier is placed, this consisting of a cage subdivided into several compartments, and in which the water rises from below. The holder is charged with water, so that when the gasometer rests on the bottom, the water is above the level

* From the maker's catalogue.

of the supply pipe leading to bottom of generator, and flows down this pipe, rising to the carbide and evolving the gas. The gas is led off by the outlet pipe through a water-dip chamber, which, although it allows the gas to pass freely from the generator, prevents any return taking place. Leaving this "seal" the gas flows on into the holder, which, rising, causes the water to fall below the level of the supply pipes, so that, after a time, the generation of gas ceases. As the gas is used the holder again falls, and having a displacement cone inside, it causes water again to rise to a sufficient level to flow into the carbide, this operation continuing automatically till the whole charge is exhausted. The subdivision of the carbide cage into several compartments, and the fact that a considerable surface of water is present at the point where the carbide is undergoing decomposition, tend to prevent overheating. On its way to the holder the gas passes through a small box containing charcoal, which acts as a scrubber and removes condensation products from it, and the gas is also washed in the water seal. As it leaves the holder it is passed through a long coiled pipe contained in the holder tank, any liquids condensed in the coil being collected in a catch-box at the bottom of the apparatus.

Another contact apparatus, resembling the last in having vertical generating chambers, is Wm. Bailey and Co.'s model B, illustrated in Fig. 35. In this the water supply is regulated by the falling and rising of the holder bell, as will be seen. The water pipes can be traced going to the generating chambers and the gas pipes coming away, but at two cross-pieces it will be seen that the water and gas pipes join and single pipes serve the two purposes. At the crosses the water pipes end in

diminishing pieces inside, so that the water falling and the gas coming away pass freely. As one generating

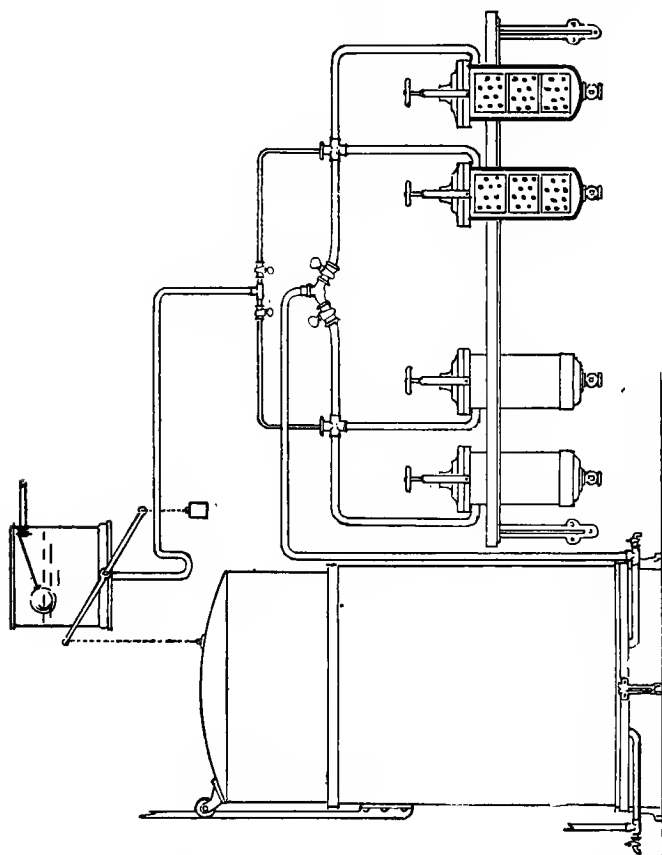


FIG. 35.

chamber becomes flooded, the water rises up and goes to the next, and when this is full it rises over the bridge and goes to the opposite pair. Any reasonable number

of generating chambers can be arranged in this way according to requirements.

The maker's directions for use, as follows, will furnish the remaining particulars.

When charging the apparatus see that all taps are closed except two bottom taps on gas holder.

Fill bottom gas-holder tank with water, and then close the two bottom taps on same.

Take off lids of generators, fill the cages with carbide. Put cages of carbide in the wire frames, place them in the generator and screw down the lids, care being taken to have the rubber ring between lid and generator flanges, so as to make a good joint. Open the two large taps, over and in centre of the two sets of generators, then open one of the two small taps immediately above the two large taps.

By opening the small tap the set of generators nearest to it are put in action, and when the whole of one set are exhausted the water rises and flows through the large taps and bridge between the sets of generators, thus automatically bringing the second set into action.

To re-charge the exhausted set of generators, close the large and small tap nearest to that set, and open the other small tap to continue the water supply to second set of generators.

The exhausted set can now be emptied and re-charged as before (care being taken that all water and sediment have been drawn off by means of the large taps at bottoms of generators, before replacing the newly charged cages). After which the large tap only must be opened, so that when the second set is exhausted the water will rise over and so bring the first set of generators again into action.

The small taps on generators are to ascertain the condition of carbide without removing lids of generators. If gas issues on opening any of these taps, the charge of carbide in that generator is not exhausted; but if on opening tap water is forced out, this shows the charge of carbide is completely exhausted; and when water issues from the small tap on outside generator of either set, this shows the carbide in that set to be exhausted and ready to be re-charged.

The small water tank can either be filled by hand or fitted with a ball-tap.

Taps on bottoms of generators are to empty remaining water or sediment after removing carbide cages, before replacing the newly charged ones.

Generators working on the Displacement Principle.—What are known as displacement generators rely for their working on the gas, as generated, being able to drive and hold back the water from the carbide until the existing volume of gas is exhausted. As the gas is used and its pressure is weakened, the water is able to flow back and wet the carbide, or a portion of it, again and make more gas, and so it proceeds until the carbide is exhausted. The gas is necessarily made and held under pressure, this, as will be seen by the following illustrations, being from about twenty to thirty inches of water. It is not a dangerous pressure of course, but it makes a governor necessary to control the issue at the burners.

The makers of the last generator, Fig. 35, also have one on the displacement principle as Figs. 36 and 37, which illustrations will make the working operations clear.

The generating chambers may be one or more, and

are fixed in an upright position against the tank. The carbide is carried in a series of trays ranged in a holder. These are readily lifted out when the gas-tight lid of the chamber is removed. When water enters the generating chamber and gas is evolved this gas immediately exerts a pressure as there is no adjustable holder to receive it. The effect of the pressure therefore is to depress the

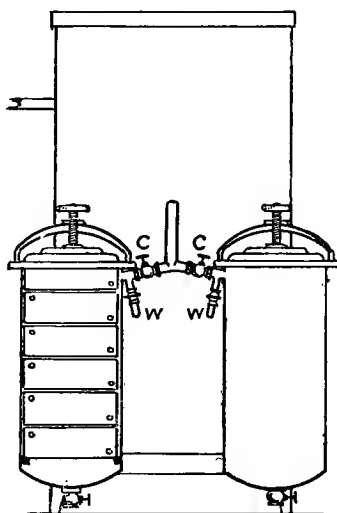


FIG. 36.

water in the lower half of the tank and make it rise in the upper half. As the water is depressed it soon leaves the water-supply pipe W uncovered, and no more water enters the generating chamber until the gas is used and the water rises again.

To start and use the apparatus, water is first allowed to flow into the upper half of the tank, and this quickly

fills the lower half provided the outlet cock is opened to discharge the contained air. The lower part is quite filled, and a few inches are allowed to lie in the upper part as shown. (The outlet cock is then closed.) The gas cocks C C are now opened, and one of the water cocks W. Water at once flows in, acetylene commences

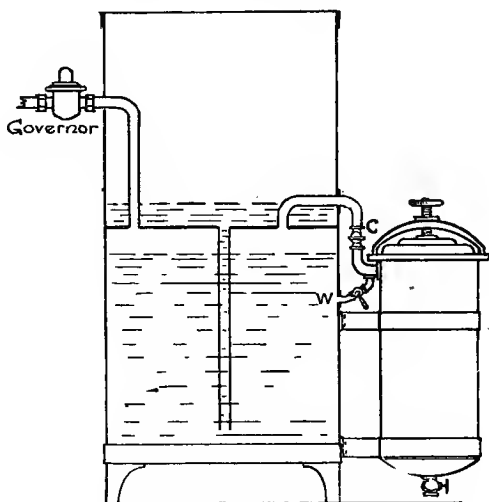


FIG. 37.

to come off and, passing by the pipe C, depresses the water in the lower tank, causing it to rise in the upper part. This, as just stated, causes the lower water to descend past the pipe W, when the inflow to the generator ceases and does not occur again until sufficient gas is withdrawn to allow the water to rise to this height once more.

A well-known contact apparatus working on the

displacement principle is that made by the Read-Holli-day Acetylene Co., Limited. This is illustrated at Fig. 38, but although only one generating chamber is

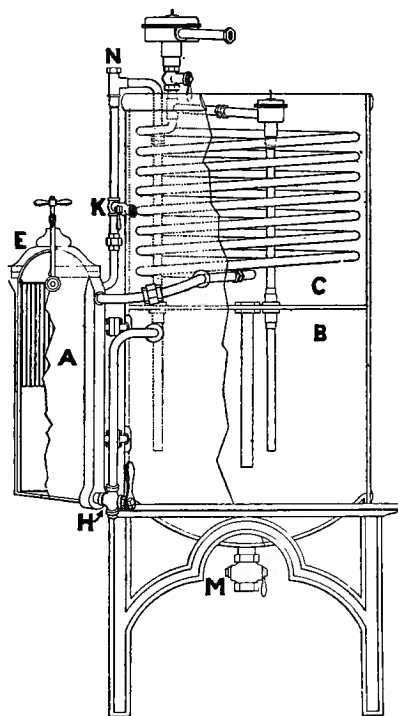


FIG. 38.

shown they are made with any number up to eight, all being fixed against the tank as shown.

The operation of the apparatus is as follows :

To first charge the machine, fill the holder B with water and about 8 inches in C, letting out the air at tap

K, having handle of tap H turned up. After filling with water, turn handle of tap H down, to let water out of generators A.

Then charge generators A with carbide.

The handle of tap H, when turned up, points in the direction of the opening through it, and should be turned down only when re-charging.

There is a wire basket and cage for each of the generators A, the former to hold the carbide, and the latter to catch the coarser lime dropping out of the baskets when working. The cage should be attached under the baskets, and the baskets charged with the carbide and then placed in the generators A. The lids E are then screwed on, and the tap H turned up.

To re-charge the generators, turn the tap H right down and run off the lime and water, open the lids E, empty the cages of residual lime, charge the baskets with carbide, and re-insert again, close lids E, then turn tap H upwards.

After charging generators A, a certain amount of air remains inside. This should be allowed to escape by opening tap K till a smell of gas indicates that all the air has escaped.

A pipe N leads from A to B to take any excess gas formed.

As a fine sediment of lime may accumulate in B, a tap M is provided underneath, which should be used occasionally to flush out this sediment.

SMALL GENERATORS, LAMPS, ETC.

There are considerable numbers of small generators made on the same principle as some of the large ones

already noticed, yet the dimensions admit of their being portable and adapted for emergency or temporary uses. They would be suited for lantern work, to light work-people in cellars, or underground, or at night. They might also be used for lighting out-door stands or stalls and many such purposes. Of these little need be said except to describe and illustrate one or two examples and show how portability is obtained.

Fig. 39 illustrates an apparatus of this class, capable of giving a 50-c.p. light for five hours, the cost of the complete outfit being about fifty shillings. The illustration shows a standard light with shade, but connection for an optical lantern can be as easily arranged. This is made by William Bailey & Co., of Manchester, and the generator works on the same principle as their larger one illustrated at Figs. 36 and 37.

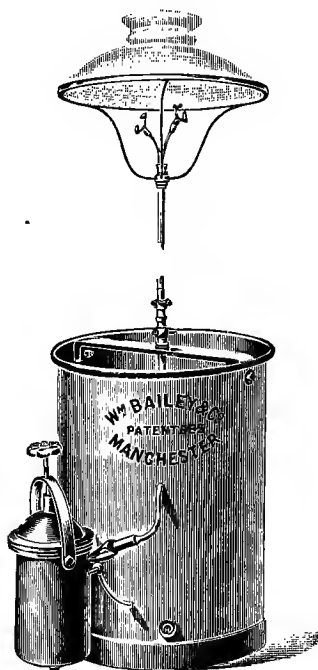


FIG. 39.

Another portable generator may be illustrated in the "Crown," shown in section by Fig. 40. This works on the dipping principle. An examination of the illustration will make its operation quite clear. The carbide carrier consists of a number of separate cells and is

dropped into the position shown. The vertical tubes act, firstly, as guides to the bell and, secondly, one as a safety pipe, the other as the gas service to the outlet at bottom. The cost is about two guineas.

Practically all makers have these small duplicates of

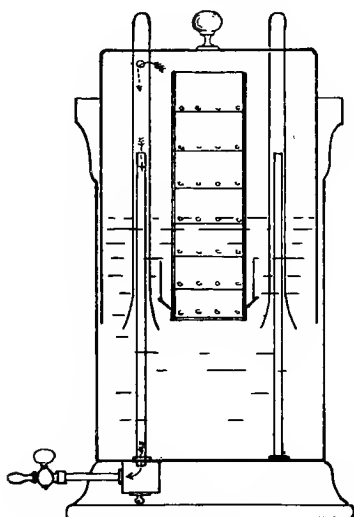


FIG. 40.

their larger machines, and consequently any lengthy description of them would be but to repeat descriptions already given.

A small amateur apparatus is illustrated at Fig. 22.

Of the firms making a specialty of portable self-contained generators and lamps, The Phôs Acetylene Syndicate probably have the greatest variety. Their "Type E" generator is made as part of wall lamps, detachable lanterns, yard and street lighting lamps, etc.

Fig. 41 illustrates the construction of this, and the makers' instructions for use are as follows :

With lever enclosed with generator, move round lever post A until it is easily removed by first lifting upper peg in its hole and then drawing post out from bottom hole. Remove door B with rubber washer C from generator opening.

Draw out carbide chamber D, open same. Half fill upper part of carbide chamber with carbide, replace

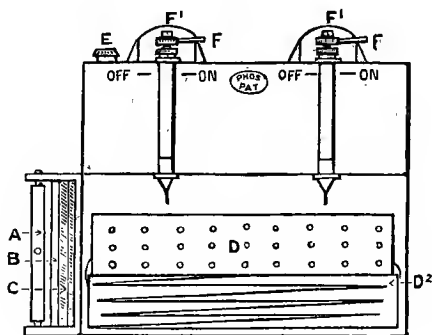


FIG. 41.

spring D^2 with plate pressing against carbide. If less than full charge is used, pull out spring a little. Close carbide container, and replace in generator. Replace door B in opening, first seeing that rubber washer C is in position. Place lever post A into position by pushing longest peg into hole at top, and allowing short peg to drop into bottom hole. Tighten up lever post as tightly as possible with loose lever, taking care to see that a gas-tight joint is made.

Draw back slide of water feed E or unscrew cap E,

fill upper part with clean water and close slide or cap. The lamp is now ready to light.

To light lamp, pull small lever F of one valve over from left to right (points are marked "off" and "on"), allow a few minutes for air in generator to be forced out, then light at burner.

To put light out, reverse the lever till it reaches point marked "off," when light will gradually die out.

It is advisable to occasionally unscrew the small screw F¹, and wipe off any dirt which may have accumulated from water on to wire, taking care not to bend wire in, doing so, and to replace same exactly in its position, being sure that wire is screwed well home.

The pressure plate and spring must press the carbide well up against the perforated top of carbide container.

Carbide of a larger size than will pass a mesh of 1 inch must not be used in this generator. Be sure there is no dust mixed amongst the carbide. 1½ lb. of carbide is a full charge.

Always use a burner consuming two-thirds of a cubic foot per hour, or 20 litres, with Type E Generator.

The two water feed valves must never be turned on together; the second valve is to be used if the charge of carbide has not been all consumed the first time of lighting up and the user wishes to re-light lamp a second time instantaneously.

Another combined generator and lamp is the "Knock-about," by the same firm as the last. This is made with swing handle and hurricane-pattern globe, and the special purposes of the lamp are such as tunnel work, shaft-sinking, camp, stable or stock-yard, etc. Fig. 42 illustrates the working parts, and the description issued is as follows:

Turn round lantern until the pegs I. I. are above slots in bottom of lantern, then lift lantern from body of generator. Undo hasps at side of generator, and lift upper part A from lower part A¹.

Unscrew screw B at bottom of generator, remove screw plate B¹, by pushing the long pin at end as far as it will go in lug B²; this releases the short pin, and all can be easily removed.

Draw out carbide container C and half fill with calcium carbide, replace spring D with pressure plate D¹, pressing well on carbide. Replace carbide container in its outer casing, taking care that washer E is well in its place. Replace screw plate B¹, and screw carbide chamber up by screw B as tightly as possible, taking care to make a gas-tight joint. Fill lower part of body A¹ with water up to marked line.

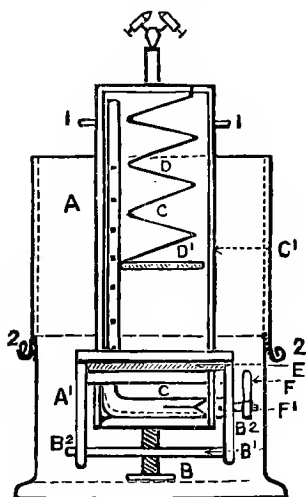


FIG. 42.

To light lamp, turn handle of cock F from horizontal to vertical position. Insert upper part of body A on to lower part. Allow a few moments for gas to generate, and then light at burner. To put light out, remove upper part A from lower part A¹, and turn handle of cock F until it reaches the point marked "off."

Carbide of a larger size than will pass a mesh of 1 inch must not be used in this generator.

Table Lamps.—The Phôs table-lamp depends on the

same working principle as the preceding, as will be seen by Fig. 43. The instructions for use are as follows :

Lift the upper part A from lower part A¹.

Lift out carbide chamber C, and fill annular space D half full of water, taking care no water gets into the central space D¹.

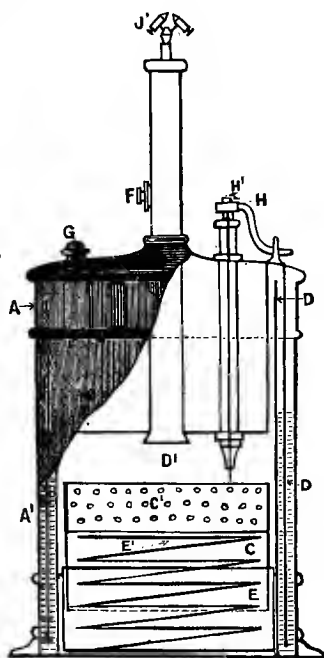


FIG. 43.

Open carbide chamber C and take out spring E. The bottom cap is fixed to carbide chamber by two bayonet joints.

Fill perforated portion of carbide chamber half full of carbide until the partitions are well covered.

Replace spring with the metal disc E^1 pressing against the carbide, and over the spring fix bottom portion of carbide chamber securely. Now replace carbide chamber in central space D^1 , with perforated portion of chamber uppermost.

To charge lamp with water, see that the handle of feed-valve H is at post marked "off," unscrew cap G from top of water chamber I. Fill water chamber I with clean water, and replace cap G. Now replace upper part of lamp A on lower part B. Do not push upper part into lower, but let it settle down gently, keeping button F pressed in, so as to allow the air in lamp to escape. When upper part is in its proper position, release button.

The lamp is now ready for lighting. To light the lamp, turn handle of valve H to post marked "on." This allows water to drop on carbide, and starts generation of gas. Allow a few minutes for sufficient gas to generate, and then light at burner J. It will be found on first lighting the lamp when charged with fresh carbide it takes from two to three minutes for the light to come to its full power, but after the lamp has been once lit and put out, on re-lighting, the full light is obtained immediately.

With a 1 lb. charge of carbide, the lamp will burn for seven hours continuously, or a succession of short periods amounting in all to about six hours.

To put light out, turn handle to post marked "off"; this stops water supply to the carbide, and no more gas will be generated. Let gas in lamp burn itself out; this it will do in about twenty minutes. Do not blow the light out, as then you would get the smell of escaping gas. Always let it burn out.

A firm making a specialty of acetylene table-lamps

is Worsnop and Co., of Halifax, but instead of using ordinary carbide they recommend a special material which they have named "acetyloid." This substance really consists of ordinary carbide subject to a treatment which renders it impervious to slight moisture and

requires the material to be immersed before it gives off gas in any quantity. Even then it gives it off more slowly than is the case with ordinary carbide. It is claimed that gas production is thus more under control and that after-generation is practically absent, as "generation ceases the moment the tap is turned off."

Fig. 44 illustrates the working parts of an acetyloid lamp, and the description which accompanies it is as follows:

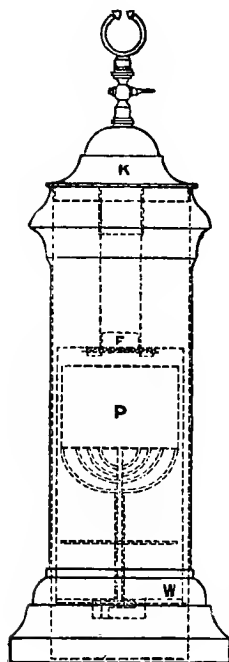


FIG. 44.

To trim the lamp for use, take hold of the top of the lamp at K, and by giving it a slight turn towards you, it will turn off the catch, and can be lifted out. Then take hold of the wire at W, turn it off the catch, and draw down the basket P.

Fill the basket P with acetyloid; about 1 lb. at a time is recommended, which lasts seven hours.

Now put a measureful of water into the lamp (the measure is supplied with the lamp); replace the basket P and put the tube into the water, and fix the lamp top as before.

The lamp is now ready for lighting. Turn on the tap and let out the air ; the gas will come in about half a minute.

The small tube in the lamp contains a gas purifier. It is taken out by turning the catch wire at F. It is divided into three compartments. The top compartment is filled with cotton wool, sponge or fabric, which should be changed when dirty. The middle compartment is filled with a chemical purifying mixture supplied with the lamp, and will last about three months. The bottom compartment may be filled with ordinary calcium carbide. This is to take the dampness out of the gas, and will last about one week ; this substance is not essential to the good burning of the lamp, but is useful to take out any dampness of the gas, which may tend to stop up the burner in time.

There is no doubt that a difficulty exists in using ordinary carbide in table lamps without an adjustable holder to receive the gas of over-generation and after-generation. If a safety valve is not provided then dangerously high pressures must sometimes be developed ; whilst, on the other hand, a safety valve, if provided, is scarcely an element of safety if it discharges acetylene into the room, as it must. In any case the free gas would be disagreeable. It would seem that in such a material as acetyloid a remedy for the risk and trouble may be found ; or in such a thing as acetone, which has the property of absorbing the gas.

If it were possible to include a miniature gas holder in the base of a table lamp without making it of unwieldly size, very good results might be obtained. The same might be said of cycle lamps, but with these also the gas holder is not feasible.

To show what has been done in designing table lamps using ordinary carbide, the following examples are given. Fig. 45 illustrates a principle which can at least claim the advantage of simplicity. Water from the upper vessel comes down to the carbide chamber by means of the syphon-shaped tube. This tube, however, is so small that the water can only fall on to the carbide in drops.

In using the lamp the upper part would be lifted off and the charge of carbide (a few ounces) put in the lower vessel. The upper vessel is then put on, secured airtight, and water poured in. Immediately following this the water would commence to drop on to the carbide and gas be evolved in the usual way. If the burner was not in use (turned on), or if gas production exceeded the demand, the dripping must cease owing to the pressure of the gas holding the water back. Should the pressure be excessive the gas would drive the water back up the syphon pipe and then escape by bubbling through the water in the vessel above. By this means the water pipe is an element of safety against excessive pressure; but on the other hand, if gas came through this way while the burner was alight it would ignite and be an alarming phenomenon if not a dangerous one. Safety would rest chiefly in making the syphon of a precise size for the water drip needed, and keeping it very clean. It may be added that water dripping on to the top of a pocket of carbide is not an ideal way of generating the gas, but in this case the quantity of material acted on is very small.

A rather more elaborate scheme is embodied in Fig. 46. In this the carbide is carried in a perforated holder contained in a generating chamber which is placed in the body of the lamp. The latter, outside the generating

chamber, contains the needed supply of water, which serves also to keep all parts cool. The water reaches the carbide by way of the pipe P, on top of which is a flap-valve. If gas is generated faster than it is used, the pressure which is felt first arrests the inflow of water, and then helps to hold shut the valve on top of the pipe. A safety valve is provided to discharge gas if the pressure becomes excessive.

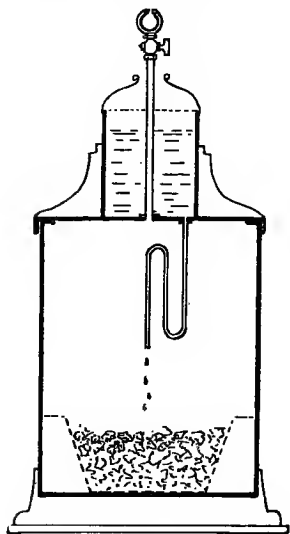


FIG. 45.

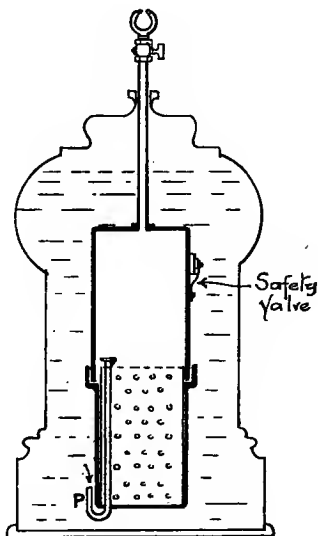


FIG. 46.

Another simple principle is that adopted in the lamp illustrated at Fig. 47. It is not automatic, but, working as a displacement generator, some provision exists for a reasonable excess of gas, as will be seen. The illustration needs little explanation. A small cage of carbide is suspended by a cord from a pin or barrel operated by the

milled head shown. To start the apparatus, the basket of carbide is lowered until it just touches the water. Gas is immediately evolved, and if it is not used as fast as made, it develops sufficient pressure to force the water down and hold it away from the carbide until the gas is

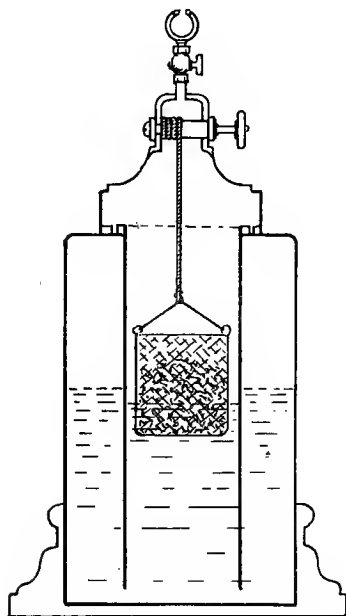


FIG. 47.

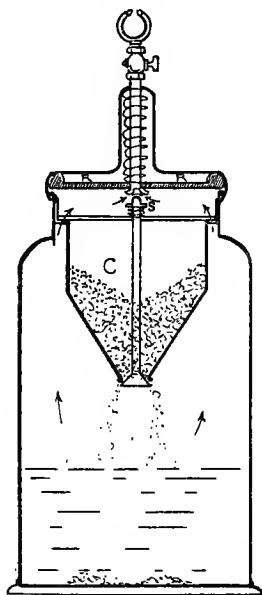


FIG. 48.

used and the pressure decreases. The carbide cage must be lowered a little from time to time when the lamp is in use. The makers place great faith in a layer of oil, on the surface of the water, preventing after-generation.

These examples serve the purpose of showing some

of the various means adopted to the one end, and they serve to point out very plainly that the perfect table lamp is not easily designed. A final example may be given to illustrate an ingenious detail, this being a carbide-to-water apparatus.

Fig. 48 shows the working parts. The carbide container C has its small bottom opening closed by a valve—a conical button—attached to the bottom of a rod passing up through the lid of the container. At the top of this rod is a knob with a small spring beneath it marked S. At R R there exists a rubber diaphragm which, when there is gas beneath, is slightly pushed up. When the gas pressure slackens, the top spring pushes the rubber down, presses on the knob at S, and this in turn causes the little button or stopper to come away from the bottom of C. When the button C descends carbide falls, more gas is evolved which elevates the rubber R R again, and this allows the spring at S to draw up the button again. Only granular carbide can be used.

Cycle and Vehicle Lamps.—In these the chief fault of the table lamp has no existence, owing to the fact that any excess of gas generated, and discharged from a safety-valve, goes into the open air ; and although this means a waste of material it causes no risk or inconvenience. The same remarks apply, of course, to lamps designed for motors or other vehicles. It is only in rooms or confined areas that over-generation and after-generation give trouble if no adjustable holder is provided to accommodate the excess of gas. It is practically impossible to make precisely the amount of gas needed, and to stop making the instant the burner is turned off. With most cycle lamps it is found desirable to let the lamp burn out when the ride is ended, and whether allowed to burn

out or put out by a tap, the lamp is best left outdoors until its charge of carbide is exhausted.

It is to be doubted if the acetylene cycle lamp will ever become popular ; it is progressive, but the light is somewhat a trial to others using the road after dark. To have the beam of light in one's face for a moment is to make the eyes useless for some seconds after, long enough to bring about an accident if riding or driving in a busy place. If riders would be content to throw the light on to the ground, as is intended, less fault could be found. Perhaps the worst offenders in causing discomfort to other travellers are the motor lamps—a blaze of light which is several times worse than a cycle lamp and sufficient to startle horses as well as make their drivers sightless for a moment. Acetylene lamps are certainly smart and go-a-head, but the majority of people using the roads can never be favourably disposed towards them.

One of the difficulties to be overcome in designing an acetylene lamp for cycle or vehicle is to allow for, and prevent, any ill effects from vibration. Water that is either trembling or washing about in the tank may not operate with the exactness so delicate a mechanism needs. A water valve set while the machine is stationary may act quite differently when the machine is in motion. Even a good and bad road may show a difference. With the displacement mode of generation, in which there is no valve, the water is not held back by the gas with anything like the degree of certainty that it is with a stationary apparatus. Perhaps the lamp which provides for the water travelling from the water tank to the carbide chamber by means of a wick offers the best solution of the difficulty, as water travelling along a wick by capillary attraction is not noticeably affected by the

vibration of a cycle when in motion. A wick, however, can soon be rendered useless if lime (from the spent carbide) gets on it, or if the water should be dirty.*

The requirements of a cycle or vehicle lamp are as follows :

The carbide is best not made up into cartridges or sticks, as an unexpected long ride or a little forgetfulness may leave the rider without a light. Even loose granulated carbide is not obtainable everywhere, but it is much easier to get than carbide specially prepared. Further than this, a cartridge is, presumably, of a fixed size, but a ride is never of any fixed duration, therefore it should be possible to vary the charge of carbide to any extent that the user of the lamp considers desirable.

The lamp should readily come to pieces to facilitate cleaning and charging. Any part that is wet when re-charging should be in duplicate so that it can be exchanged for one that is dry. This would scarcely be the metal parts unless the user was careless, but in some lamps there are pads of felt or muslin material that do not readily dry and which should be in duplicate on this account, one set drying while the other is in use.

It is very desirable that the lamp when lighted and adjusted prior to starting the journey should not require re-adjusting when the vibration commences. As previously explained, this end is not very easy of attainment, and the next best measure is to make this extra adjustment possible without dismounting.

* It quite usually happens that a ride is commenced in daylight and ended after dark, in which case, although the lamp may be charged with carbide, the water is not put in until lighting-up time. Water is then obtained from the nearest available source, which, occasionally, may be a pond or ditch.

The carbide, whether the charge be small or large, must not rattle or jump about in its container. It must be held down, yet there requires to be the ample space necessary for the lime of decomposition.*

It is equally desirable that the gas pass through a filtering medium, such as muslin or a thin layer of cotton wool, before arriving at the burner. This will rid it of water (or solid particles if the carbide should shake about), keeping the burner clean and lengthening its life of usefulness.

A final detail relates to the burner. A lamp should carry a needle for clearing the burner orifice (if it is a burner that will admit of this), and provision is now usually made for attaching the cycle pump at a point which will admit of the burner being blown through if necessary. In many lamps, as already stated, it is desirable to let the gas burn itself out, but this is favourable to the burner orifice getting sooted up, and on this account alone cleaning conveniences should be provided. It is also a desirable provision when the burner gets into bad condition away from home.

An example in which a wick is used as the medium for conveying the water to the carbide is Read-Holliday's "Yahr," illustrated by Fig. 49. It will be seen that the inner carbide chamber is surrounded by a water tank or jacket, and a wick tube passes up the centre. The wick tube is open to the water space at the bottom. On top of the carbide is placed a piece of wire gauze, and the spring shown above keeps the gauze in position and the carbide from shaking about. The wick is composed of several strands, so that the ends at top fall over and lie

* The lime or sludge left after the carbide is exhausted occupies about double the space the charge of carbide did.

on the gauze in all directions. This ensures water coming to all parts of the charge alike. The purpose of the screw at top with milled head and rubber washer at bottom is that by screwing it down on to the top of the wick tube the flow of water can be stopped and generation be made to cease.

The makers' directions for use are as follows: Fill the outer chamber with water by means of the screw plug provided. Fill the inner chamber with broken carbide

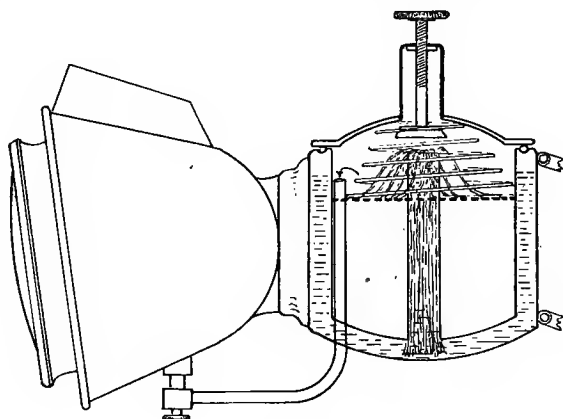


FIG. 49.

to within half an inch of the top. Put in the spring and the gauze disc on top of carbide. Moisten the wick, then push it down the central tube to the bottom. Arrange the loose ends of the wick to rest on the gauze. Place on the lid and secure it, then light burner. The small screw under the burner requires to be removed occasionally to allow any condense water that collects there to run out. To shut the water off and stop making gas, screw down the piston at top until it presses on the wick.

If more immediate cessation is needed, the wick can be taken out so that its wet ends are removed from the top of the carbide.

Fig. 50 will illustrate how a cycle lamp is made to work on the displacement principle. The body of the lamp is a cylindrical water vessel into which a tin cartridge of carbide is inserted. The cartridge is water-tight except for a pin-hole at the bottom. The cartridge would

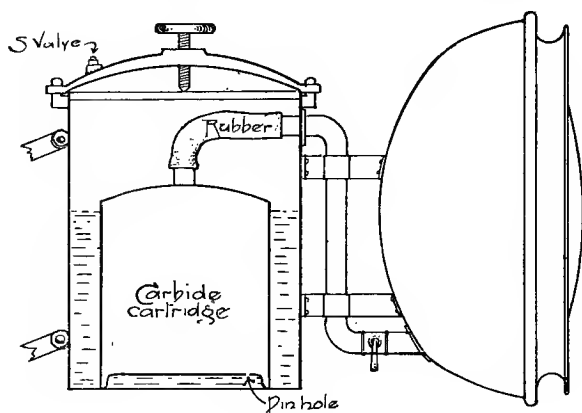


FIG. 50.

be inserted into the case before the water is added ; then on adding water, some would enter the pin-hole and cause gas to be generated. The gas passes away by the tube at top to the burner, but when the gas is generated in excess of what the burner takes, a light pressure is exerted in the carbide chamber sufficient to drive and hold the water back out of the pin-hole until the pressure slackens and more gas is needed. It will be noted that the connection between the carbide cartridge and the

burner tube is a piece of rubber pipe. This is rather a weak detail. A lamp of this kind is useless without special cartridges, unless a cartridge case were made with a fitted top which could be opened and refilled as required.

Another example, in which the water rises to the carbide but is driven and held back by any excess of gas, may be illustrated in the "Veritas," Fig. 51, which is made for either cycle or vehicle. The carbide holder fits within a casing, between the exterior of which and the outer wall of the lamp body the water is held. This lamp works on the displacement principle as the space F, shown full of water, serves to receive any excess of gas made by its forcing the water to ascend into the exterior space above. The pin or spindle operated by the milled head X is always screwed upwards, so that the opening at the point of it is open and clear, except when the lamp is about to be re-charged. The point at which the water first comes in contact with the carbide is at the small opening marked E, called the distributor. The makers' instructions accompanying the lamp are as follows: To charge the lamp, first screw the valve X down. Then fill the water chamber H quite full, through the filling socket I. Unscrew the bottom of lamp and half fill the carbide chamber G with small carbide (or fill it to a less extent if the lamp is only required for a short time). Replace the carbide chamber and unscrew the valve X to its fullest extent. The water will then flow through the tube B into the chamber F, and from here it will rise up the centre tube and out through the distributor E. Gas will then be evolved and the lamp may be lighted. The valve X must be left full open while the lamp is in use and is only closed to stop generation.

At J there is a needle which can be passed through the burner to clean it. A head is fitted to the top of the generating parts, and this carries the lens and reflector. The latter are not shown, the section coming across the side lights.

What appears to be the favourite principle of generation for cycle lamps is the dripping of water into the

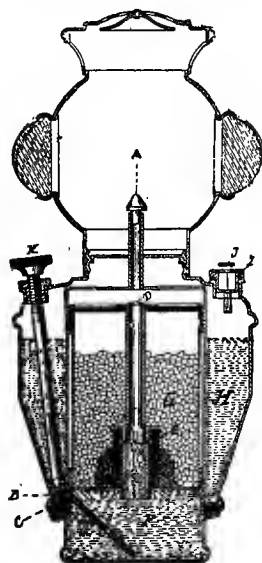


FIG. 51.

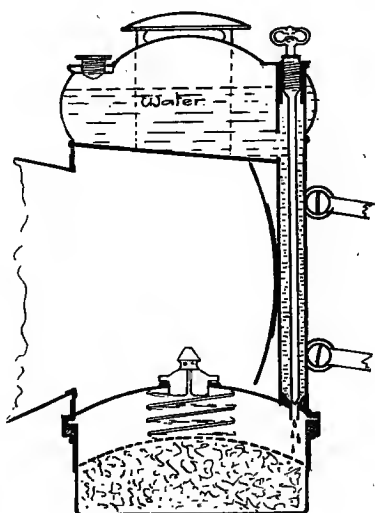


FIG. 52.

carbide chamber. There must have been at least twenty to thirty lamps designed and patented all working on this one principle but varying in detail.

Fig. 52 illustrates a lamp of simple construction working in this manner. The water vessel is at top, where marked, while the carbide chamber is at the bot-

tom as shown. A gauze cover rests on the carbide, this being held in position by the spring shown. From the water tank to the carbide chamber is a communicating tube which is opened or closed at the bottom by the cone ended pin. This wire or pin figures largely in lamps working on this principle, as by its operation the dripping of the water is regulated. In many the wire is termi-

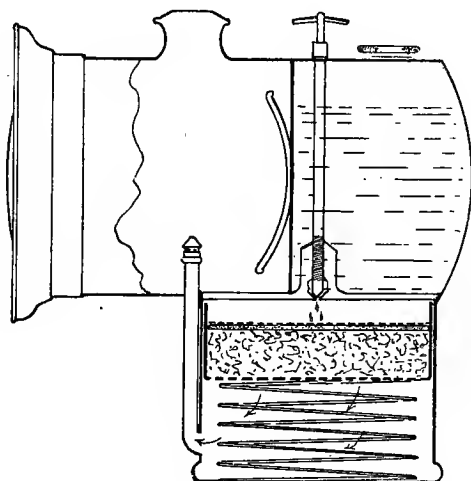


FIG. 53.

nated at the bottom with a needle. The cone still closes the opening, but the needle goes beyond and its movement keeps the small bottom passage clear of dirt; it also directs the drip, as the water then falls from the end of the needle.

A final example can be given in Fig. 53. As in most lamps the water reservoir is at top and the carbide chamber below. The open cup which carries the carbide

is pressed up from below by the spring shown, and above the carbide comes a sheet of blotting-paper, and above that wire gauze. The gas, as made, does not get away from the top of the carbide chamber, but is made to pass downward through the carbide which effectually dries it.

It may be mentioned in conclusion that a carriage or motor lamp should be designed with a view to substituting a candle-tube in place of the generator (the lower part of the lamp) if necessary. The candle-tube should in fact be supplied and carried. A choked burner, or broken nipple, or a failure with the carbide renders the vehicle next to useless, supposing such an event occurs during a journey and when out in a remote place, or at any time in fact. The generating part too should be designed with a view to adapting it to existing candle lamps.

CHAPTER V.

THE PURIFICATION OF ACETYLENE.

Too much importance cannot be attached to the bearing that generators have upon the purity of the resulting gas. The carbide bore all the blame once, and doubtless deserved much of it, but now the case is different. There are still impurities in carbide, and the gas which comes from it, even when generation takes place under the most ideal conditions, but they only just deserve the name and they make themselves as inconspicuous as possible if the generator maker will assist in this end.

It is not the intention, however, to deprecate the use of a purifier by any means but, on the other hand, to distinctly and strongly recommend that one be used always, without any allowance for supposed or real good qualities in the generator. What it is so desirable to mention and have clearly understood is that really bad gas is often, almost always, chiefly due to the generator, and that although the normal impurities accompanying acetylene should and must be removed * they do not account for the unbearable results that are frequently found to accompany the use of the gas.

At the time of writing, about half the people that may be asked have a bad opinion of acetylene, either from personal experience or hearsay. They are people

* Except in open factories, foundries, brickworks and the like.

who would be willing to speak well of the light if they could. The generator maker is accountable for this state of things far more than the carbide, or the attendant, or the burners and appliances, or the few who have fooled with the gas and paid the penalty. The cry is that the gas when burned leaves a smell, it is dirty, it is troublesome to make and in other ways ; it makes a haze, the burners soot up, it comes expensive, and other things. Every one of these complaints are traceable to the generator, and to prove it the writer can refer to one of his own apparatus which has been working two winters without a purifier of any kind, and which has the ordinary Naphey type of burners still giving a nice flame, though untouched the whole time, and the other troubles have no existence. The Acetylene Co.'s carbide is being used, and beyond this there is nothing to favour good results except the construction of the generator. Notwithstanding this it is best to use a purifier in all residence or similar installations. It should not be omitted. It is desirable with a good generator and necessary with a doubtful one.

It may be briefly stated that the impurities due to bad generation, those which would be absent or scarcely noticeable with perfect generation, are brought into existence by the heat developed in the generating process and by there being no water for the gas to bubble through and be cleaned of those impurities which water can abstract. Purification is effected, to a certain and considerable extent, by passing the gas through water, and this detail of the gas production should be included in the generating apparatus or be made a part of the plant in some way. Briefly stated, the gas should pass through water immediately after it is evolved from the carbide

and before it enters the holder. If the generator should be one that makes the gas under favourable conditions, then, after the water has abstracted the ammonia and sulphur, the only impurity passing over to the holder is phosphuretted hydrogen, and this is abstracted in another way as the gas leaves the holder. By referring to Fig. 1, p. 7, this plan of dealing with the gas will be seen, viz. the gas passing through water as it passes from generator to holder, then through a chemical purifier as it passes from the holder to the house service.

When, however, the gas is generated under bad conditions, with excessive heat, other impurities are brought into existence. The heat may set up secondary reactions and polymerisation. Tarry products, also benzine, are sometimes produced, and while water will remove many of these, there is a distinct loss of acetylene due to their existence. It is not at all uncommon to see a tinge of yellow in the exhausted lime, showing clearly that tar is present, whereas nothing of the kind should appear.

The sum and substance of this is that preventive measures should be adopted towards securing pure gas, and these are simply cool generation and making the gas pass through water as fast as it is made. Cool generation is obtained by having a sufficiency (or an excess) of water come to the carbide in the generating chamber. An insufficiency of water is practically the chief cause of really bad gas, and the next is allowing the water to drip on top of the carbide which is in too great a bulk or mass so that the water does not attack it freely. These details, of course, relate more to generator construction than the purification of the made gas, but it remains a fact that generator construction has much, very much, to do with the pure or impure qualities of the gas yielded.

After the gas has parted with all the impurities and useless vapours that the water in the condenser can abstract it is customary to let it pass to the holder and give it its final purification as it leaves the holder to go to the burners. It will bear repeating here that the purifier is best not placed between the generator and the holder, owing to the fact that chemical purification is best effected when the gas passes through the purifying material gently. Between the generator and holder the gas passes rapidly at times, rushes through in fact, and the abstraction of gaseous impurities, like phosphuretted hydrogen, cannot be properly done under these conditions ; at least, not so successfully as when the gas flows through gently.

There are not many different means of purifying acetylene chemically, at present. They all rely on some material or compound having an affinity for the gaseous incondensable impurity, therefore arresting it in its passage through, yet without arresting or abstracting any of the acetylene. As all these materials arrest the impurities by absorbing them, it follows that the purifier must become used up and inert in time and require re-charging. This is the case, and all purifiers require to be re-filled at stated periods depending on the nature of the material used, the volume of gas passed through, the size of the purifier and the way the gas is generated.

If the gas, as made, is passed through water it may be considered that the only one of the impurities requiring special treatment is the phosphuretted hydrogen. This is the gas which chiefly causes the haze that occasionally appears. It is a fault of the carbide, not the generation, as the quantity of phosphuretted hydrogen is not materially affected by good or bad generation, either way.

This impurity would not make itself so obvious if it were not for the water vapour always present in the air; and as living apartments generally hold a more humid air than outside, the trouble is intensified. When phosphuretted hydrogen is consumed with the acetylene it undergoes a change into a pentoxide of phosphorus. This in itself would be slightly visible as a white haze, but it quickly becomes combined with water vapour, and the result is that the haze becomes more visible and increased to quite a great extent.

There are at present three substances which have the power of absorbing phosphuretted hydrogen from acetylene without absorbing the latter or giving it any new or bad qualities. The chief and most common one of these is calcic-chloride (chloride of lime or bleaching powder); the second is the acid subsalts of copper, which forms the basis of Frank's purifying earth; the third being chromic acid, a process sometimes bearing Dr. Ullmann's name.

When chloride of lime was first commercially used for this purpose it was found, as now, that it was best mixed with some inert substance, and sawdust was chosen for this. The results were distinctly bad, and some time and many experiments were expended in discovering that the fault lay with the sawdust. It became evident that the lignin of the wood-dust and the chloride underwent a chemical change together, producing some free chlorine, considerable heat and loss of purifying properties. The difficulty is now overcome by mixing the bleaching powder with an absolutely inert substance such as powdered coke, brickdust, infusorial earth, etc.

A purifying material known as Puratylene consists of a granulated mixture of ordinary lime and bleaching

powder.* This has a good effect in that the lime tends to absorb moisture and so keep the moistness of the bleaching powder within reasonable bounds. It is desirable to have the latter moist, but not so much so as to make it pasty. It is considered that Puratylene will purify acetylene in the proportion of one pound to 600 cubic feet of gas.

In another purifier the makers have the different limes in muslin bags, which are laid on successive trays one above the other with about a 2-inch space between. The bags are flat and very loosely filled so that the lime is scarcely a quarter of an inch thick. The ordinary lime is a drying agent, while the chloride purifies. It is very desirable to let the gas pass through a little quicklime after it comes from the chloride. This can be easily done with the bags mentioned.

Wolff's purifying mixture is bleaching powder with a little lead chromate.

Still another means adopted for utilising bleaching powder is to mix it with oxide of iron.

It is very desirable, and should be considered essential, when using bleaching powder, that the generating process include some means of washing the gas, by making it bubble through water, to rid it of ammonia and excess of sulphur, but particularly the ammonia. The next purifying agent to be mentioned rids the gas of all three of its ordinary impurities (phosphuretted and sulphuretted hydrogen and ammonia), but this is not the case with chloride of lime purification, and washing should be resorted to. As already mentioned more than once, the introduction of a washing device is no objection, but distinctly the reverse. It would be well if it

* In porous lumps.

appeared in every apparatus, except the carbide-to-water systems with which the gas cannot well avoid being washed without a special device.

The second material named, acid subsalts of copper or Frank's solution, removes not only the phosphuretted hydrogen, but the sulphur and ammonia impurities.*

To render it convenient of application the liquid is added to an inert solid, the infusorial earth known as Kieselguhr being used for this. The earth so impregnated has been named Frankolin. For large demands Frank prefers to bubble the unpurified gas through the purifying material (hydrochloric-acid solution of cuprous chloride) in its liquid form, as by a filtering and boiling process it is possible to regenerate the fluid and by the addition of a little copper and hydro-

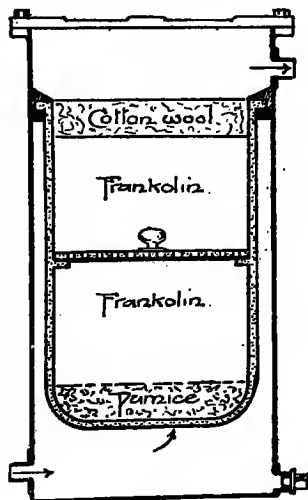


FIG. 54.

chloric acid to bring it up to full strength again. This, however, is not a desirable process for apparatus on a moderate or small scale, and the addition of the earth makes it much more convenient for use.

Fig. 54 shows a Frank's purifier in sectional detail, and the instructions issued regarding it are as follows :

* This does not make washing any the less desirable, as water cools and cleans the gas and is helpful generally. Frank recommends washing the gas after it has gone through his purifying agent.

Unscrew and take off the cover, remove the earthenware pan and thoroughly clean the inside of the purifier.

Connect the inlet of the purifier to the generator, fixing a stop-cock between the gas holder and the purifier, which should be shut off when the installation is not in use for a lengthy period. The outlet should then be connected to the gas supply pipes, using a drop syphon and plug to prevent any moisture, formed by condensation in the pipes, running into the purifier.

Varnish the iron rim inside the apparatus and the adjacent metal parts to ensure the putty adhering to the metal. Cover the rim with putty and replace the earthenware pan, taking care to press down the flange evenly all round.

Carefully fill in the space between the pan and the sides of the apparatus with putty to make a perfectly sound and gas-tight joint.

Put in a layer of about 3 inches of pumice stone, to prevent the "Franklin" falling through the perforations and to allow the gas to enter freely. Fill loosely with "Franklin" to within about 3 inches of the top; then fill in the remaining space with cotton wool to arrest any free acid which might be carried out of the chemical with the gas.

The perforated centre plate is put to the larger sizes to prevent the mixture from settling down too compactly to allow the gas to percolate through it.

If the purifying earth is lumpy it should be carefully crushed before being put into the apparatus.

Refix the cover and screw same down gas-tight by means of the rubber washer.

The purifying material should be stored in a wooden box or barrel, and should not be put into a metal vessel,

on account of the free acid it contains. It should be kept dry, but does not deteriorate by exposure to the air.

"Frankolin," with which the earthenware vessel is charged, is sold loose at $10\frac{1}{2}d.$ per pound, and it is claimed that one pound will purify 600 to 800 cubic feet of acetylene. The earthenware vessel carrying the Frankolin, it should be noted, is necessary because of the free acid present. Enamelled iron could be safely used instead if it were desirable.

The third material, chromic acid, is made into an acidulated solution by means of sulphuric or acetic acid, and the process is patented by Ullmann. It is a liquid as its name implies, and is used either in that form or with the inert earth kieselguhr, the same as Frank's solution last mentioned. The acid solution of chromic acid removes all three impurities, viz. phosphuretted and sulphuretted hydrogen and ammonia, and it can be regenerated.

Fig. 55 will serve to illustrate a typical good arrangement for a purifier—not necessarily the only good plan of construction, but one that ensures purification while the material used is good and active; and the necessary recharging is by no means difficult. This is patented by Bailey and Clapham.

The external appearance is that of a plain upright cylindrical case, with a cast lid having an air-cock in it, and two pipe connections as shown. On removing the lid a metal lining is discovered which carries a series of trays. On each tray is a muslin bag of purifying material (in a thin loose layer); the apparatus is thus made a chemical filter, which every purifier, using dry material, is. At the bottom, where the gas enters, is a perforated

chamber containing slag-wool which arrests solid impurities held in suspension, also partially dries the gas coming from the washer. This lower chamber has to be bedded on its ledge in a sound gas-tight manner, and the upper casing soundly on this, otherwise gas would get through from the inlet to outlet without passing through

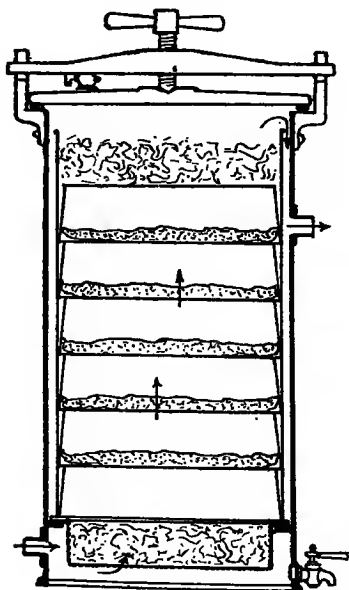


FIG. 55.

the purifying material. There is a chamber at top also carrying slag wool, the utility of which is not so perceivable unless it is that with rushes of gas some of the dust material in the upper bags might be carried over. There is the possibility of this, and in any case the slag wool, if in a loose condition, does no harm. The drain-

ing tap at the bottom of the case is a desirable provision ; as is also the air tap at top which admits of the contained air being discharged each time the purifier is opened and closed for re-charging.

As stated previously, the purifier is best put on the house side of the holder, not between the holder and generator. Purification is best done by an even flow of gas, which is best secured on the house service. Between the generator and holder there must occur rushes of gas, the gas going faster than a normal area of purifying material could well deal with. Slow purification must be more perfect than quick when there is but a given quantity or area of purifying material.

CHAPTER VI.

BURNERS AND APPLIANCES.

IT is considered in a general way, that the perfect burner has yet to be designed; not but what we have burners which consume the gas perfectly, but they all become choked with soot at some time. Burners of the Naphey and similar type (to be described) do occasionally, in fact frequently, remain clear and free of soot, and this would make it appear that the fault may not be so much with the burner as the quality of the gas. This point will be discussed later.

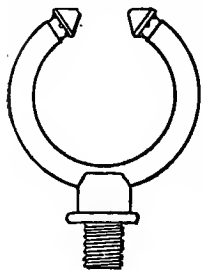


FIG. 56.

When the gas first came into general use it was burnt at ordinary burners or jets, of small size, and it was quickly found that under the best available conditions the burners usually had to be changed about every hundred hours. This led to the introduction of the Naphey burner, Fig. 56, which is a kind of Bunsen burner on a small scale. In the first place, the best illuminating results were obtained, as usual, by arranging that two jets impinge, but this has to be effected, in the present case, by two widely separated orifices as shown. Each arm of the burner delivers a plain pin flame, and upon these two flames

impinging a flat flame results. Fig. 57 shows the pin flame from one of the arms, the tip of the other being



FIG. 57.



FIG. 58.

temporarily stopped, while Fig. 58 shows the resulting flat flame that is obtained.

The chief detail of the Naphey burner, and the many burners now made on that principle, is the provision of air holes leading from the exterior of the nipple to the mixing chamber, or hollow, in the centre of the extreme tip. Fig. 59 will make this clear, it being a section of the nipple (steatite tip) two or three times enlarged. As the gas issues it draws in air which mixes with it, the result being a whiter flame, more perfect combustion and freedom from smoke. It does not make the flame blue like an ordinary Bunsen burner, the supply of air being insufficient for this.

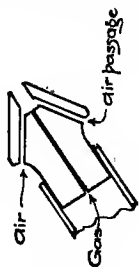


FIG. 59.

There is not the least doubt that the principle embodied in the Naphey burner is good and practical, yet while some of the burners do good service for a long time,

others carbonise, as it is called, rather soon, the orifice at the tip becoming choked with or bridged over (or both) with a black soot material. This has been such a common trouble that fine needles with handles are made and sold expressly for clearing the tips when they need it. Some time ago, when the carbide could reasonably be blamed for impurities and their effects, the burners may have owed much of their carbonising qualities to the raw material; but the English carbide now used is comparatively pure, and it is doubtful if much, if any, of the fault at the burners can be initially due to it.

Little hesitation need be felt in blaming the generator or the absence of some necessary detail in the generating plant, when burners behave so badly. If one burner only of several on one installation gave trouble, then the fault might be looked for in the burner or the gas service to it, but as a rule all the burners in a house give more or less trouble, if any do at all.

Cool generation, washing and purifying lengthen the burner's life of usefulness, to which must be added that the flames (at the burners) must not be turned low. It is a little fault that acetylene has, that the lights cannot be turned low in unoccupied rooms. They must be fairly full up or quite out. The reason of this is that with only a bead of flame at the tips, the air is not drawn through the air passages, and if this does not take place the gas is apt to deposit soot at the burner orifice, as previously explained. It does not hurt to turn the gas low now and again for a few minutes, but to leave it two or three hours may choke the burner in one evening.

The cause of burners becoming sooted up or carbonised is the subject of some little doubt as yet, although theories and reasons are offered to account for it. It is

pointed out that on splitting a steatite tip which has been suffering in this way, the carbonisation is found to extend into the solid material of the tip, soaked in so to speak, showing that the substance has been in a liquid form. Benzine and tarry vapours, the products of excessive heat in generation, could readily account for this, and it is reasonable to lay the blame, or most of it, here.

The best possible effort has been made to use a Bray type of burner, with very fine holes, first on account of the low cost, and secondly because of the economical lighting duty obtained from them. Professor Lewes designed one with the union jet holes at an obtuse angle to cause a better insuck of air; but although highly successful in giving a light equal to about 40 candles per foot of gas burned, they had the weakness of this kind of burner, when used with acetylene, of beginning to smoke after a few hundred hours' use even with good clean gas. A smoking acetylene flame will deposit soot about a room in a very unpleasant way. The writer uses the Bray 00000 to 000 acetylene burners for special purposes, and nothing could excel the light they give for the gas consumed; but for ordinary lighting purposes the Naphey or atmospheric type of burner has to be fallen back upon.

A most important thing that the lighting engineer must realise is that burners decrease in their lighting qualities, for a given volume of gas, as they decrease in size. It is equally important that the common idea of acetylene giving a light of fifty candles per foot should be swept away. Under experimental conditions with a 000 Bray burner (just mentioned), 240 c.p. has been obtained from 5 feet of gas, but this was under "best conditions."

As the ordinary Bray acetylene burner cannot be used for general purposes and the atmospheric type must be resorted to, the illuminating power of the gas is considerably diminished, and quite a different value must be given it in all lighting calculations. Professor Lewes has published the following table, which gives the comparative figures for all sizes very clearly. This relates to the ordinary Naphey type burners.

Number of Burner.	Pressure.	Gas Consumed.	Light.	Candles.
	inches.	cubic feet.	candles.	per foot.
6	2'0	'155	0'7938	5'3
8	2'0	'27	3'2	11'6
15	2'0	'40	8'0	20'0
25	2'0	'65	17'0	26'0
30	2'0	'70	23'0	32'85
42	2'0	1'00	34'0	34'0

From this it will be seen that distinctly the best results are obtained with the larger burners, yet the one-foot burner only gives a light of 34 candles. There is no record as to what result this large burner gave with the pressure increased to four inches, for it is not considered that a two-inch pressure is sufficient for best results with any burners above the No. 15 size. Two-and-a-half inches are given to a half-foot burner, and it yields about 24 c.p. light per foot. It will therefore be seen that to call a half-foot burner a 25 c.p. size is totally wrong.*

* It may be here stated that the lighting power of burners is calculated upon the light they give for an hour, burning a given quantity of gas; thus a half-foot burner has an orifice which only permits half a foot of gas to

To the best of the writer's belief, no maker or factor sells burners by their actual candle-power. Some give the consumption of gas for the various sizes, whilst others give a number only, this number being of their own making and having no universal meaning. This being so it will always be safe and best to calculate the efficacy of good burners on the table given on p. 158. Very few atmospheric burners can give better results, and then only a trifle better, if any.

As many burners come from Germany and other Continental countries, and their nominal consumption is given in litres, the conversion of their ordinary sizes into English cubic feet measurements must be of use.

Litres.	Cubic feet.
6	= $\frac{1}{8}$
10	= $\frac{1}{5}$
15	= $\frac{1}{3}$
20	= $\frac{2}{3}$

Litres.	Cubic feet.
25	= $\frac{5}{6}$
30	= 1
40	= $1\frac{1}{3}$

A last general detail relating to burners is the pressure of gas with which they give best results.

The question of pressure is considered to a much greater extent with acetylene than with coal gas. In the first place, acetylene is heavy, and instead of requiring but a fraction of one-inch (water) pressure it needs two inches or more. It is therefore easier to get a smoky flame, which is a fault of a pronounced kind. On the other hand an excessive pressure causes a greater pecuniary

pass through it in one hour (if the pressure is regulated), and this, from the figures just given, should be called a 14-c.p. burner. A bad habit has grown up amongst people, who have not studied the subject properly, of calling a one-foot (per hour) burner a 50 c.p. value for rough calculations, and giving all smaller burners a proportionate rating. In the first place a one-foot burner has probably never given a light of fifty candles for an hour, and no smaller size has yet given results proportionate to the larger ones.

waste with acetylene, as a cubic foot is so many times more valuable than the same volume of coal gas. A little leakage or waste of coal gas is not thought much of, but it is different with acetylene; therefore the pressure should be set nicely and, by the use of a governor, closely worked to. By the latter means flaring wasteful flames are impossible.

From the writer's experience the following pressures give satisfactory results. It can be easily seen whether the pressure is correct by examining a flame when the burner is turned fully on. It should not flare, nor should it be dull. It must be a perfectly noiseless and motionless flame, a dazzling white at night or a dazzling whity-straw colour by day. It should be so free of motion as to look like brilliant wax, if this can be imagined. The flame is susceptible to draughts of course, but not so much so as a flame issuing at less pressure.

PRESSURES AT WHICH ACETYLENE SHOULD BE CONSUMED TO
OBTAIN THE BEST LIGHT WITH ECONOMICAL WORKING.
THESE PRESSURES AT THE BURNERS.

Litres.	Cubic feet.	Pressure in inches of water.	Litres.	Cubic feet.	Pressure in inches of water.
6	. . $\frac{1}{6}$	. . 2	25	. . $\frac{5}{8}$	. . $3\frac{1}{2}$
10	. . $\frac{1}{3}$	. . 2	30	. . 1	. . 4
15	. . $\frac{1}{2}$	. . $2\frac{1}{2}$	40	. . $1\frac{1}{3}$	. . 5
20	. . $\frac{2}{3}$	. . 3			

The simple instrument for testing pressures is described a few pages further on.

It is important to remember, as mentioned in an earlier part of this book, that an exactly suitable and economical pressure cannot be obtained at all burners on a plant if the burners vary much in consumption of gas.

A glance at the table just given will make this plain. It does not matter, however, if the burners vary a little in size, but to put half-foot and one-foot burners on the same piping means setting the governor for the large burners and relying on adjustment of the bracket taps for the small ones. It is therefore better, where possible, to use burners closely alike in size, and if a large size is required to work with small ones use a double or triple flame burner as illustrated further on. This means using two or three small flames instead of a single large one, and the pressure suited for the small flames will then suit all.

The variety of burners on the market is now considerable, and it is practically impossible to notice them all. It must, therefore, be sufficient to describe those possessing some specially useful or novel feature so as to illustrate the principles that are worked to.

The burner as in Fig. 60 is an ordinary Naphey type burner, but of a different shape to that illustrated at Fig. 56.

The double and triple burners just referred to resemble Figs. 61 and 62.* These are of the Naphey type, as will be seen, and need no further description. The effect obtained is pretty.

The "Phos" burner, Fig. 63, is novel in the fact that provision is made for clearing the gas orifice in the steatite tip when required. The illustration shows one arm of the burner in section, and the needle within it is operated

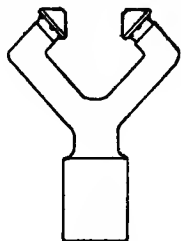


FIG. 60.

* These and most of the burners illustrated appear in the catalogue of Falk, Stadelmann & Co., Ltd.

by the milled head screw shown. The single-jet cycle lamp burner made by this firm has a fixed needle inside, and the clearing of the gas orifice is effected by screwing down the top of the burner.

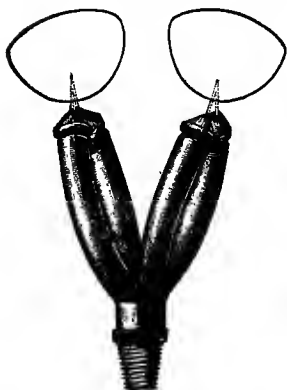


FIG. 61.

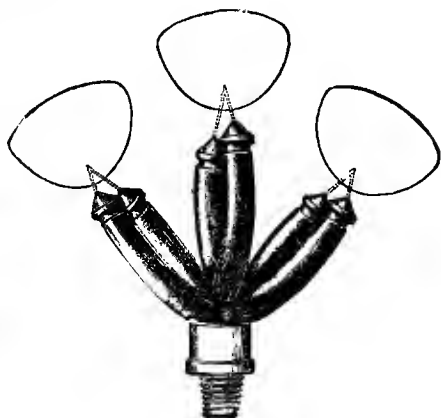


FIG. 62.

It has been stated on high authority that two-armed metallic burners like those already described in this chapter, are affected by the heat so that the two arms get out of alignment. The consequence of this would be a distorted flame lacking in illuminating qualities. To overcome this difficulty, burners are made with the arms—the whole of the upper part of the burner in fact—in steatite, and are largely sold and used. There is doubtless something in the statement, but the writer has used and sold a large number of metallic armed burners, and has them in use in his office

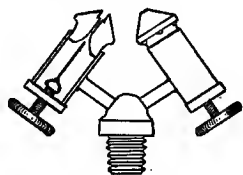


FIG. 63.

and home, and it has never been his experience to have a burner go wrong in this way. Not infrequently the fault is discovered on first lighting a burner, which probably indicates injury in packing, but a little pressure with the fingers puts the burner right. The burners with all-steatite heads are said to keep a true alignment. It is a matter of taste and experience. The all-steatite are more readily broken than the metal: the metal heads, if they become untrue, can be put right with the fingers.



FIG. 64.

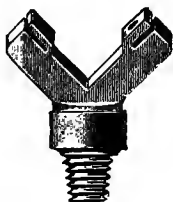


FIG. 65.

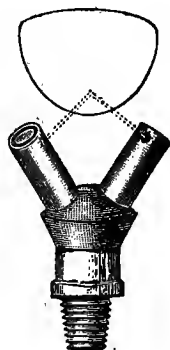


FIG. 66.

Figs. 64, 65 and 66 illustrate some burners with steatite heads; the first two are all steatite above the collars, while the third one has steatite prongs or arms. These illustrations serve to show some of the means resorted to for the needed supply of air. Instead of holes two have slots cut, while the third has an annular channel.

Considering that our best authority attributes the failure of burners by carbonisation chiefly to a liquid hydrocarbon soaking into the steatite tips, it would be

thought that an enamel or glass tip might be substituted with advantage. Fig. 67 shows a burner made with glass prongs and tips.* The writer has no experience of the burner, but it is claimed not to "smoke, plug, carbon or get out of alignment ; burns equally well with a low flame ; any unsatisfactory burner will be exchanged or the money returned."

For large single flames a bat's-wing burner has been designed, as Fig. 68,† which is made in different sizes



FIG. 67.

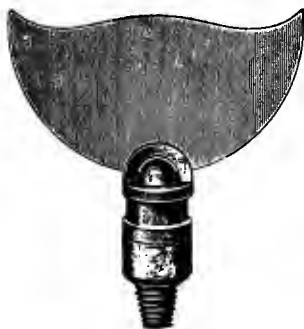


FIG. 68.



FIG. 69.

from 100 c.p. upwards. It is an efficient burner, the result of experiment and experience.

For the reverse of the foregoing, viz. small flames, as may be required in servants' passages or in unimportant bedrooms, a single needle-flame can be had by using a burner as Fig. 69 and giving a flame resembling that sketched.

* Sold by the Harriman Carbide Co., 29 Broadway, New York.

† These special, also ordinary burners, are made by J. von Schwarz, of Nürnberg, and factored in England by L. Wiener, of 1A Fore Street, London.

It has been stated that the acetylene flame cannot be turned low (in an unoccupied room for instance), for if left a few hours in this condition it will most probably carbonise. The burner has to be turned moderately full on or quite out. To overcome this difficulty is the function of a bye-pass burner such as is illustrated by Fig. 70.* When the light is not required the small pilot jet shown is left burning, then when turning on the



FIG. 70.

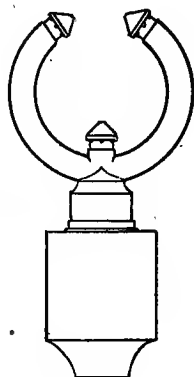


FIG. 71.

full supply of gas to the burner the flame is immediately ignited. The chains shown are for use when the burner is out of reach or is otherwise inconvenient of access to turn out and relight as required. In such places the pilot light is of real service.

Quite another kind of bye-pass burner is that which can be operated at a distance. This is essential for railway station lighting, or even for single lights that

* See last footnote.

cannot be worked by chains or similar means. As acetylene flames cannot be turned down (without spoiling the burners) it follows that the means ordinarily adopted with the platform gas lamps, of stations out of London, cannot be adopted, as this is simply an arrangement by which all the flames are turned low by one cock.

The bye-pass burner that admits of one or many being worked by one distant main tap is that supplied by the Forbes Acetylene Gas Co. of Regent Street, Kensal Green, London, and its external appearance re-

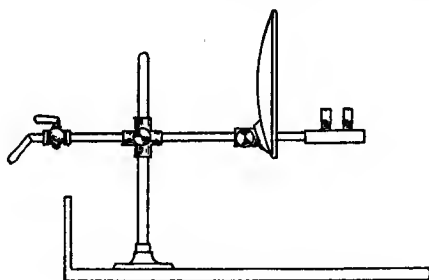


FIG. 72.

sembles Fig. 71. By a very simple internal arrangement the pressure of gas is made to work the lights. When the gas cock is full open and the pressure highest, a passage to the burner tips is cleared and a full flame results. On turning down the gas and reducing pressure the passage to the pilot light only is left open. It is a very useful device as there is practically no limit to the number of burners that can be operated by one main cock.

For lantern work acetylene is admirably adapted, offering greater facilities perhaps than lime-light. Fig. 72 illustrates a typical lantern fitting which can have two or

three burners of any power. It is essential that a generator be chosen which is not "tricky," neither failing with its light nor making too much gas and discharging it into the room.

For photographic work acetylene offers special advantages and no doubt will be used very largely at some early date. It is a strongly actinic light, yet does not proceed from a point and thus cast heavy shadows like the electric arc, and soft effects are obtained. It can be used for night work or to assist dull winter daylight. It does not affect the pupils of the eyes, like some powerful lights, and for this and several other reasons it is obviously very superior to magnesium flash-light.

Of course the period of exposure is controlled by many things, but working with a good portrait lens, full aperture, quick plates, and twenty 50 c.p. burners in the reflector,* from three to five seconds (according to the effect desired) is sufficient. Fig. 73 shows the usual kind of reflector used. It is sheet-metal painted or whitewashed inside: there is nothing elaborate as will be seen. The Read-Holliday Co., Ltd., of Huddersfield, make a much better style of apparatus with a white enamelled concave iron reflector adjustable as to height, angle, etc.

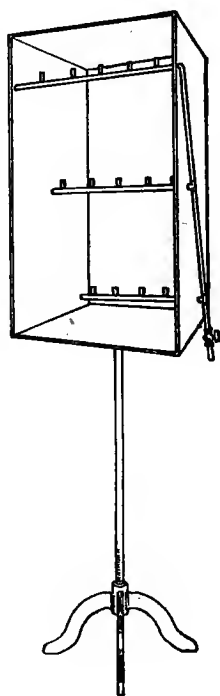


FIG. 73.

* The Bray burner is generally used.

For best effects in portraiture, the light is thrown directly towards the sitter, but between the two is interposed a screen of thin oiled tissue paper, nearly transparent.

A "governor" should be considered an essential detail in every installation except those of smallest size. The pressure of gas in the service pipes and at the burners should be automatically controlled or governed with every gas system, but with acetylene it is especially desirable as a waste entails greater pecuniary loss than with coal gas. A flaring burner (and servants will not

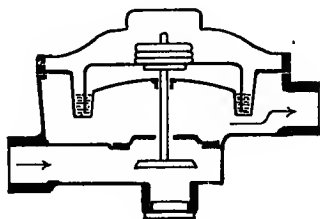


FIG. 74.

regulate the taps with nicety) means a waste of gas, gas burned to no advantage; and as a cubic foot of acetylene costs about as much as fifteen cubic feet of coal gas it will be seen what a source of loss an uncontrolled burner can be if the gas is at a high pressure in the pipes.

Reliable governors are made by Strodes, Stotts, Peebles and others. They are mostly "mercurial," the governing float working in a circular mercury bath as Fig. 74. This is Peebles' design and is regulated or set by small circular weights put on at the top. It will be noticed that the addition of weights increases the flow of gas, not decreases it as might be supposed. The governor

made by Fletcher, Russell & Co. has no mercury bath and is operated by a diaphragm.

These governors are ordinarily made for coal gas which is burned at a pressure probably under one inch of water. As acetylene requires from two to four-inch pressures the governor is made accordingly, and the fact of its being required for acetylene must be stated to the maker when ordering.

In setting the pressure of an acetylene lighting installation, by means of the weights or other device on the governor, a pressure gauge must be used. This is readily made in the workshop if an elaborate article is not required, and the same gauge is quite suitable for testing the soundness of the piping. It is a good and correct plan to test the piping when finished, but before connecting to the governor or generating apparatus. The test is to ascertain if the joints are soundly made or if there is leakage from any other cause, a split pipe for instance. The test for this should be with 10 to 14 inches of water, and, if the gauge is left on for about fifteen minutes it will plainly show whether the piping is sound or not.

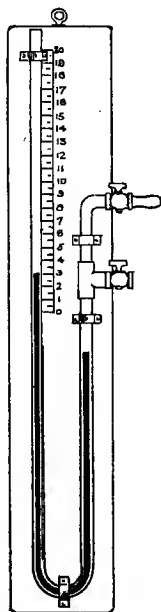


FIG. 75.

Fig. 75 illustrates the gauge referred to. The back is a piece of plain wood about 24 inches by 4 inches. On this is a syphon-shaped piece of $\frac{3}{8}$ or $\frac{1}{2}$ inch glass tube. This tube can be purchased at about one penny per foot, and the bending can be easily done in an atmospheric gas flame. An ordinary luminous gas flame

gives heat enough but it blackens the tube. Where shown there are two cocks, one to attach to the gas service or bracket and one to blow into when the pressure test for the piping is made. At a point where shown a zero line is made, and above this is marked off a scale of half-inch divisions. Each division will show a pressure of 1 inch as the pressure measurement is taken between the two water levels. On the illustration the water is shown black, and it will be seen that the levels are three half-inch divisions above zero and a similar distance below. There is therefore a space of 3 inches between the two levels, and the scale against the upper level shows that at 3-inch pressure exists.

In use, if the piping is to be tested for soundness, the gauge is attached to the main as near the generator as possible. All bracket taps are closed, or the drop pieces capped or plugged. The glass tube is then filled with water until it rests level at the zero line. The blowing tap is now opened and blown into until the water indicates a 10-inch to 12-inch pressure. The tap is then closed, and while the upper water level remains against the figure named it may be known that the whole piping system is subjected to this pressure provided no stop cocks are closed. If the water level remains moderately constant for fifteen minutes the piping may be passed.

To test for working pressure at the burners, when adjusting the governor, the gauge is attached to a bracket or fitting (not too near the generator) by a rubber tube, and if the two water levels are at zero while the bracket tap is closed, then on opening the latter the gas pressure will immediately alter the levels and indicate the pressure on the gauge. No blowing or assistance is needed, of course, the actual pressure of gas in the pipes altering the

water levels, as will be understood.* This test is made the last thing before putting the burners on, or before putting the last burner on. The rubber tube cannot conveniently be attached to a burner, otherwise the test might be made after all the burners were put on.

In regard to gas fittings for use with acetylene there is little to be said. Several makers certainly have exerted themselves to produce new designs of brackets and pendants to suit this dainty little light, and the result has been that many of the fittings resemble electric brackets and electroliers in elegance. The use of these specially designed fittings is much to be recommended, for they suit the light and go far to make it attractive from a commercial point of view.† It may be mentioned that besides making special designs for the metal work, new and very nice forms of cups and globes have been made to suit, the total effect being most satisfactory.

Two important details of acetylene fittings, which have not been overlooked by manufacturers, are the taps and joints. These must be acetylene proof. Acetylene is more searching than coal gas, finding and passing through a leak, or badly jointed fitting, more certainly. Common fittings, either unsound when new, or quickly wearing so, should not be used. They soon bring about a loss of gas and consequent odour.

Good quality ordinary fittings can be used, but it is better to have the specially made long bodied cocks and joints. There is also a cup-and-ball joint made ex-

* The blowing cock is only used when an artificial and excessive pressure is needed in the pipes to test them.

† The makers of gas fittings specially designed for acetylene which have come to the writer's notice most prominently are Falk, Stadelmann & Co., of Farringdon Road, London; and Joyner & Co., of Icknield Square, Birmingham.

pressly for acetylene. All are obtainable from the firms named in the footnote on p. 171.

Gas stoves for burning acetylene, for boiling purposes or for heating irons, appear in trade catalogues and are claimed to work satisfactorily with a low pressure of gas. This is not easy of attainment, as the volume of gas is so small for the quantity of air required that the former needs be delivered at fair pressure to carry sufficient air in. To burn acetylene for heating purposes only is the reverse of economical compared to coal gas, but where the convenience is of paramount importance then the stoves may be successfully employed.

Acetylene, when consumed, yields about double the heat units that coal gas does for a given volume. In other words, it is of double the effectiveness when put to any heating purpose. This would make acetylene much to be preferred if it cost the same as coal gas, but as the two are worth approximately forty shillings and three-shillings per thousand feet respectively, it will be seen that acetylene is only practicable for heating when the expense is not objected to.

CHAPTER VII.

LEGAL AND OTHER REGULATIONS GOVERNING THE STORAGE OF CARBIDE AND THE FIXING OF ACETYLENE GENERATING APPARATUS.

THE following is a copy of a licence to keep or store calcium carbide, such as is issued by a country District Council. This represents the documents which lighting engineers are most likely to see, or have to work to, and it is therefore recommended that it be carefully read and its contents committed to memory, as far as possible.

No. _____

LICENCE TO KEEP CARBIDE OF CALCIUM.

(34 & 35 Vict. c. 105, ss. 7, 9 ; Order in Council, 26th February, 1897.)

We, the ^(a) _____ in pursuance of the provisions in that behalf of the Local Government Act, 1894, the Petroleum Acts, 1871 to 1881, and the Order in Council of the 26th

(a) *Insert* "mayor, aldermen, and burgesses of the borough of _____, acting by the Council"; *or* "urban [*or* rural] district council of _____"

Lighting by Acetylene.

February, 1897, by virtue of which certain parts of the last-mentioned Acts are applied to Carbide of Calcium in the same manner as if the said substance were Petroleum to which the Acts apply, and on the application of _____

_____ being the occupier of premises situated _____
Do hereby license the same (hereinafter called "the licensee") to keep Carbide of Calcium until the _____ day of _____, 1_____, and no longer, upon the said premises subject to compliance with the conditions following, that is to say :—

- (1) That the licensee provide a Store for his Carbide of Calcium at a spot approved by the Council [marked on a plan to be annexed to this licence, *and at a distance of not less than _____ yards from any dwelling house or other building*] ^(b) and not in the immediate neighbourhood of any open fire, forge, or other source of danger, nor in the immediate neighbourhood of any large store of inflammable, combustible, or explosive goods.
- (2) That the store be constructed of incombustible material throughout,^(c) and be provided with adequate means of ventilation, so that any gases evolved from the Carbide of Calcium stored therein may be effectually carried off and the possible formation of an inflammable or explosive mixture in the interior of the store be prevented.

(b) Cases sometimes arise in which the condition imposed by the words in brackets cannot be complied with, as for example, those cases in which the applicant for a licence has no back yard or outer premises. In such cases, the choice necessarily lies between the refusal of the licence altogether, or the granting it without the insertion of the words in italics. No universal rule can be laid down to meet all possible cases, because the course to be adopted must be determined to a great degree by local considerations and the exigencies of trade.

(c) In the event of a licensee placing his store at a considerable distance from other buildings, it would not be necessary to insist upon an uninflammable construction, though it is in all cases to be recommended.

- (3) That the store be subject, before use, to the approval of the Surveyor or other officer to be appointed by the Council.
- (4) That no Carbide of Calcium containing impurities liable to cause phosphoretted or siliciuretted hydrogen to be evolved in such appreciable quantities as to render liable to spontaneous ignition the gas produced by the action of water upon the Carbide be kept at any time upon the premises.
- (5) That the quantity of Carbide of Calcium to be kept at any one time on the premises do not exceed—lbs. ; and that all such Carbide, except so much as may be required for immediate delivery, or may form a charge of not more than two lbs. in a suitable portable apparatus for generating acetylene gas, be kept in the store.
- (6) That the Carbide of Calcium, except when in use in suitable apparatus for generating acetylene gas, be kept only in substantial hermetically closed metal vessels so as effectually to prevent the Carbide being brought into contact with moisture, and that it be not conveyed to or from the store otherwise than in such vessels, and not in the same vehicle with any Gunpowder or other explosive, or with any article likely to cause fire.
- (7) That only such quantities be conveyed to the shop or place of retailing as may be required for immediate delivery, and then only in such vessels as aforesaid.
- (8) That not more than 112 lbs. of Carbide of Calcium be kept in any one vessel.
- (9) That no Carbide of Calcium be kept in or used in connection with any vessel or apparatus constructed in any part of copper.
- (10) That any vessel containing Carbide of Calcium be opened and kept open only for such time as may be necessary for removing therefrom any part of such Carbide or for refilling such vessel.

- (11) That any residue of spent or partially spent Carbide of Calcium removed from any vessel or apparatus be immediately and without any delay mixed with at least ten times its bulk of water.
- (12) That any vessel or apparatus containing Carbide of Calcium used in connection with the licensed premises be entrusted only to capable persons properly instructed in its manipulation.
- (13) That no inflammable article be kept or deposited in the store.
- (14) That no fire or artificial light capable of igniting inflammable gas be permitted to be brought into or near the store at any time ; and that no person be allowed to take into the store any matches, fusees, or other articles likely to cause fire.
- (15) That the store be kept locked at all times except during the receipt and delivery of the Carbide of Calcium ; and that all ventilators or openings in the same be so protected as to prevent the accidental or malicious introduction of ignited materials from the outside.
- (16) That due precautions be at all times taken for the prevention of accidents from fire or otherwise.
- (17) That the licensee comply with all the provisions of the Statutes and Orders in Council which apply to Carbide of Calcium.

Given under the COMMON SEAL of the^(a) _____
 this _____ day of _____ 1 _____.

*The Common Seal was hereunto affixed at a
 meeting of the said Council by _____

 in the presence of _____
 _____* }

(a) Insert " corporation " or " district council " as the case may be.

NOTE.—Under the *Petroleum Act*, 1871, any licensee violating any of the Conditions of his Licence is to be deemed to be an unlicensed person (s. 9); and such a person is liable to forfeit all Carbide of Calcium kept by him, and to a penalty not exceeding £20 a day for each day during which such Carbide is so kept (s. 7).

A vessel containing Carbide of Calcium must, under penalty of forfeiture of the vessel and its contents and a sum not exceeding £5, have attached thereto a label bearing in conspicuous characters the words "Carbide of Calcium," "Dangerous, if not kept dry," and with the following caution: "The contents of this package are liable if brought into contact with moisture to give off a highly inflammable gas," and with the addition —

- (a) *In the case of a vessel kept, of the name and address of the consignee or owner.*
- (b) *In the case of a vessel sent or conveyed, of the name and address of the sender.*
- (c) *In the case of a vessel sold or exposed for sale, of the name and address of the vendor.*

(s. 6; Order in Council, 26th February, 1897).

In Germany the practical use of carbide of calcium for acetylene lighting and other purposes is in a more advanced state than in England,* and an extract of the Fire Insurance rules must be instructive. It may be added that these rules are the outcome of a meeting and discussion between the German Fire Insurance Companies and the German Acetylene Union, and it indicates a good and progressive feeling since the rules were formulated in an amicable manner, by those having, so to speak, opposed interests.

* In that country the acetylene gas engine is an accomplished fact, several different makes existing, some quite satisfactory in use.

*Conditions for the installation and use of acetylene gas apparatus, accepted by the Association of Private Insurance Companies in Germany.**

In addition to the observance of the local police regulations already in force, the completion of an insurance is dependent upon the strict fulfilment of the following conditions :—

The gas-holder must be provided with an arrangement for blowing off an excess of gas as soon as it is filled to its utmost capacity ; the safety-pipe for this purpose must be conducted into the open-air.

The installation must be provided with a purifying apparatus, in order to eliminate phosphoretted hydrogen and ammonia in so far as is necessary to prevent spontaneous combustion or the formation of explosive compounds.

Generators and gas-holders must not be placed in sheds or stable-buildings, unless the spaces used are completely isolated from the adjacent spaces by walls of non-inflammable materials, without any openings whatsoever.

The space in which the various apparatus are placed must not be used for the storage of inflammable substances, must be well ventilated, always locked, and only entered by persons on duty, who are strictly forbidden to smoke.

The preparation, storage and use of compressed or liquid acetylené is not permissible. The expression, compressed, applies to acetylene which is subjected to a pressure of more than one atmosphere.

In those cases in which an acetylene installation is not provided with a heating apparatus, or some suitable arrangement for the prevention of the formation of ice, the connecting pipes between generators and gas-holders must be provided with water-jackets, and must possess the following breadths :—(a) $\frac{3}{4}$ -inch for an installation under 20 jets with an hourly consumption of 20 litres per jet ; (b) 1-inch for an installation of from 20 to 40 jets, with an hourly consumption of 20 litres per jet ;

* From 'Acetylight.'

(c) $1\frac{1}{2}$ -inches for an installation of from 40 to 100 jets, with an hourly consumption of 20 litres per jet; (d) $1\frac{3}{4}$ -inches for an installation of more than 100 jets.

In the generating or apparatus chamber of an installation not exceeding 500 jets, not more than the tenfold amount of the daily consumption of carbide may be stored: one drum, however, containing 100 kilos. (1.kilo = $2\frac{1}{4}$ lbs.) is allowed.

In the generating or apparatus chamber of an installation of more than 500 jets, no more carbide than is necessary for the daily consumption may be stored; the generating or apparatus chambers of such installations, inasmuch as they contain large quantities of carbide, are to be considered as carbide storage chambers.

A carbide drum, or any vessel containing carbide, must only be opened when two-thirds of the contents of the one previously opened have been consumed. Drums or vessels which have only been once opened must be covered with a tightly-fitting, overlapping, and water-tight lid of iron-plate.

Carbide storage chambers must be light, dry, and well ventilated; they must be completely isolated or at a safe distance from the generating and apparatus chambers and inhabited buildings, and must not contain any easily inflammable substances.

Rather more elaborate is the set of rules that has been issued by the American Fire Insurance Underwriters' Association.

*Rules adopted by the American Fire Insurance Underwriters' Association.**

It is desirable that all acetylene gas generators be installed outside the building. Machines installed inside the building must be made of iron or steel, and must have sufficient carbide

* From 'Acetylene Gas Lighting.'

capacity to supply the full number of burners during the maximum lighting period.

The generator must produce gas only as immediate consumption demands, and gas must be generated without excessive heating at all stages of the process. Excessive heat tends to change the chemical character of the gas, and may cause its ignition.

Apparatus not requiring pressure regulators must be so arranged that the gas pressure cannot exceed three inches of water.

The generator must be provided with a pipe by which gas can escape in case of over-production. This excess gas must be conducted to a suitable point outside the building, and be discharged at least twelve feet above the ground level.

In apparatus requiring a pressure regulator the gas pressure must not exceed 3 lbs. to the square inch, and there must be an additional safety blow-off attachment between the pressure regulator and service pipes.

Back flow of gas from the holder must be automatically prevented, or there must be an arrangement which will make it impossible to charge the apparatus without first closing the supply pipe to the holder, or to any other generating chambers.

The apparatus must contain the minimum amount of air when first started or recharged. A device permitting mixture of air with the gas, prior to consumption, except at the burners, is not allowed. Machines should be so designed that the formation of such explosive mixtures is impossible.

Valves or pet-cocks must not open into the room from the gas-holder. The condensation from all parts of the apparatus must be automatically removed without the use of the valves or mechanical working parts.

The water supply to the generator must be efficient.

Not more than 25 lbs. of carbide is to be in any machine where water is introduced in small quantities or where the contact of water with carbide is intermittent. Danger of overheating is thus reduced.

There must always be open connection either to the gas-holder or to the blow-off pipe into the outer air so as to prevent dangerous pressure within or the escape of gas from the generating chamber.

The residuum must not clog or affect the working of the machine, and it should be capable of being conveniently handled and removed.

Covers to generators must be securely fastened in place, and those with water seals must be submerged in at least 12 inches of water. Water seal chambers for covers depending on a water seal must be $1\frac{1}{2}$ inch wide and 15 inches deep; 9 inches is sufficient for those which depend upon the filling of the seal chambers for the generation of gas.

The holder must be of sufficient capacity to contain all gas generated after lights have been extinguished.

The bell portion must have a substantial guide for its upward movement, preferably a central guide, and a stop acting about 1 inch above the blow-off point. The proper action of the bell is thus ensured, and the liability of gas escaping is also lessened.

There must be a space of at least $\frac{3}{4}$ inch between the sides of the tank and the bell.

All water seals must be so arranged that the water level may be readily seen and maintained.

In gas-holders constructed upon the gasometer principle, the lip or lower edge of the gas bell must always be submerged in at least 9 inches of water when the gas bell is filled to its maximum.

The supply of water for generating purposes must not be taken from the water seal of any gas-holder constructed on the gasometer principle. The object of this is to retain the proper water level in the generator.

The apparatus must withstand fire from outside causes without falling apart or allowing the escape of gas in volume. Soldered joints are not, therefore, permissible. Gauge glasses are not allowed.

Purifiers must conform to the general rules for the construction of other apparatus and allow the free passage of gas. The use of mercury seals is prohibited.

The deposits of lime or other foreign matter must be guarded against so that liquid seals shall not become thickened. Accidental syphoning of the water must be rendered impossible.

Flexible tubing, swing joints, packed unions, springs, chains, pulleys, stuffing boxes, and lead or fusible piping must not be used on apparatus, except where failure would not vitally affect the working or the safety of the machine. The maximum number of lights to be maintained, and the amount of carbide necessary for a single charge, must be plainly marked on each machine.

As regards the storage and use of calcium carbide, the following rules have been made :—Calcium carbide must not be stored in bulk, but must be packed in screwed-top, water-tight metal cases, having all seams lock-jointed and soldered. Each case must not contain more than 125 lbs. of carbide, and must be marked "CALCIUM CARBIDE, KEEP DRY." In charging the generator, clean all residuum carefully from the containers and remove it at once from the building. Separate any unexhausted carbide, return it to the container, and add new carbide as required. The container should not be more than half full, as the swelling of the carbide when in contact with the water has to be allowed for. Water tanks and water seals must be kept filled with clean water. Do not approach the apparatus with a lighted match, candle, or other open light.

The use of liquid acetylene or gas generated therefrom on a building insured with any of the associations who have adopted the above rules is absolutely forbidden.

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